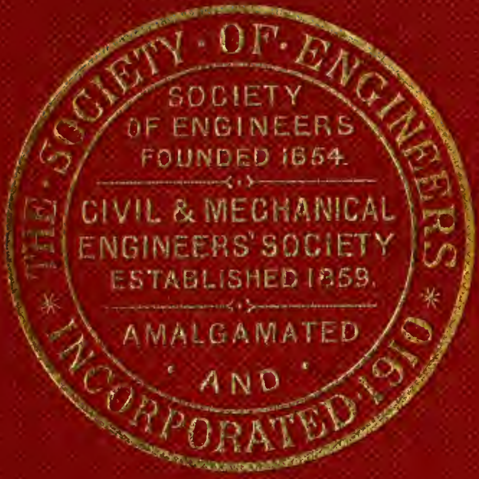
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ARTHUR VALON,

President of The Society of Engineers (Incorporated), 1913.

(See page 5.)

(THE)

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(INCORPORATED).

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EDITED BY

A. S. E. ACKERMANN, B.Sc.(ENGINEERING),
A.C.G.I., A.M.Inst.C.E., M.R.S.I.
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WALTER ARTHUR VALON,

PRESIDENT OF THE SOCIETY OF ENGINEERS (Incorporated) FOR THE YEAR 1913.

Mr. Valon, whose portrait will be found at the beginning of this volume, was educated at St. Laurence College, Ramsgate, and subsequently articled to his father, the late Mr. W. A. McIntosh Valon, who was President of the old Society of Engineers in 1893.

At the end of five years, when his articles had expired, Mr. Valon was appointed Assistant Engineer to the Ramsgate Corporation gas, water and electricity departments, and also for other work, including the design and construction of a scheme of improvement comprising quay walls, deepening the harbour, and the construction of a viaduct on arches.

In 1892 he obtained the silver medal for first place in the honours grade of the City and Guilds examination in gas engineering.

From 1897 until the present time he has practised as a civil and consulting engineer, his practice including gas works, waterworks, sea walls, bridges, roads, and outfall sewers.

Besides the design and construction of various engineering works, he has been engaged in the promotion of and opposition to private bills in Parliament, in arbitrations with reference to transfer of gas undertakings to local authorities, in making valuations for rating purposes, and similar matters.

He is a member of the Institution of Gas Engineers, a member of the Institution of Waterworks Engineers, and an Associate Member of the Institution of Civil Engineers.

THE SOUTH-EASTERN COALFIELD.

By Bernard L. Rigden.

[*This Paper was read in October last before the Crystal Palace Engineering Society (affiliated to the Society of Engineers, Inc.), but the novelty and importance of the subject are such that no apology is needed for bringing the essay before a wider public. At the time the paper was read the author was a second year student at the Crystal Palace School of Practical Engineering*].

The opening of a coalfield in the South-East of England is one of the most important commercial enterprises of recent times, but notwithstanding this fact, the development of the project has been regrettably slow, partly on account of the conservatism which is said to be one of our national characteristics, and in part due to the opposition with which this undertaking has been met by a section of the Press.

A long time before any borings were put down, in fact before coal was generally supposed to exist in Kent or Northern France, scientific men and geologists had hinted at its presence in those localities, and the theories which were formulated on the subject were subsequently proved to be correct, first in France and later in England.

It is twenty-three years since the presence of coal was actually proved by a bore hole, yet even now the coal is not brought to the bank in any marketable quantity. On the other side of the Channel the seams were proved, and coal put on the market in large quantities within twelve years of its discovery, the find having been made by accident in the process of boring an artesian well ; but it must be remembered that in France the first seam is only 500ft. below the surface, whilst in Kent the first seam lies at a depth of 1,250ft. and the last at about 3,500ft. Although this latter depth would appear to be very great, it has been demonstrated that coal can be economically won from a greater depth than that of the lowest seam in the Kent Coalfield.

The South-Eastern coalfield is situated in the County of Kent, about seventy miles from London, and is separated from the Continent by the Straits of Dover, roughly twenty miles in width. It comprises practically the whole of East Kent, and underlies land which has hitherto been devoted exclusively to agriculture.

Many things which go to make a progressively industrial country are present in this favoured district. In addition to the coal, which is of varying qualities suitable for different uses, there are valuable beds of fireclay of various qualities, some

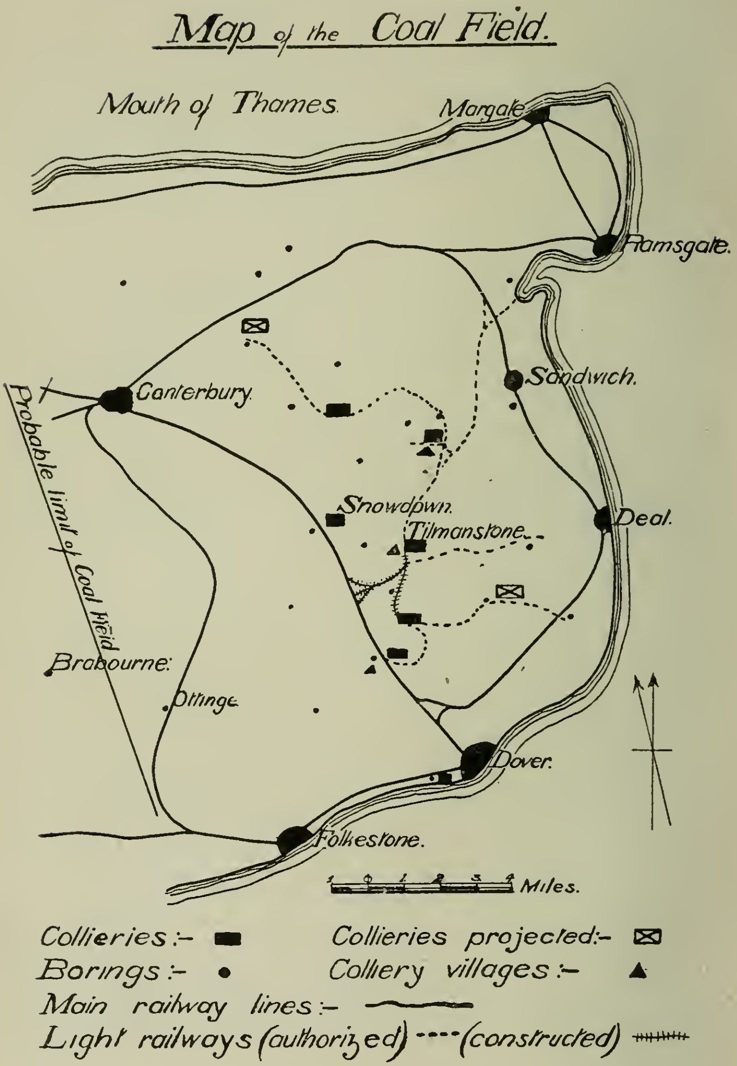
Map of the Coal Field.
Mouth of Thames.
Margate
Ramsgate.
Sandwich.
Canterbury
Probable limit of Coal Field
Snowdown.
Tilmanstone
Deal.
Brabourne.
Ottinge
Dover.
Folkestone.
1 0 1 2 3 4 Miles.
Collieries :- ■
Collieries projected:- ☒
Borings :- •
Colliery villages :- ▲
Main railway lines :- ——
Light railways (authorized) ---- (constructed) ++++++

FIG. 1.

varieties being well suited for making fire-bricks and others for the manufacture of high class pottery. There is also an abundance of limestone and iron ore.

It is impossible to predict the far-reaching effects of the development of this enterprise. The exodus of manufacturers and shipbuilders from the banks of the Thames will most certainly cease when coal is mined in the vicinity and the cost of transport saved: the Sussex ironworks, whose blast furnaces were shut down, by Act of Parliament, in the reign of Queen Elizabeth on account of the deforestation which they caused (mineral fuel being unknown at that period), will be re-started.

To analyse in detail the periods of time which elapse during the geological formation of a coalfield, is more than the author is prepared to do; but it is necessary to describe briefly the process of its formation, which has gone on during ages almost beyond computation in ordinary units.

The series of seams of coal, called the coal measures, which lie at various depths below the surface of the ground in many parts of the world, are the decayed remains of forests, of a kind different from those which we now see, whose vegetation flourished and died in prehistoric times. Each seam in itself represents a forest which grew to maturity, decayed, and was embedded beneath subsequent accumulations, the matter which buried each layer being in turn covered with new vegetation, which went through the same process. This cycle of operations was repeated many times, each repetition resulting in an addition to the number of seams of coal. In Kent there are over one hundred and thirty seams, and in South Wales about eighty.

At the time when the coal measures were in process of formation, a great forest probably covered a large part of Europe and Asia, in a practically unbroken expanse from Wales to Japan. The decay and inhumation of this forest formed the strata called the coal measures, which possibly at one time extended as unbrokenly as the original forest itself, but in succeeding ages were so distorted and disintegrated by movements of the crust of the earth that they are now accessible in only a few favoured districts.

During the time referred to, which is called the coal age, it is assumed that the land was subjected to a series of upheavals and subsidences each of which was permanently registered by a seam of coal, denoting a forest grown to maturity, decayed, and buried. The seams were of varying thickness, probably depending on the length of life of the forest. Then a change took place, the earth-crust sank finally, the sea overflowed its bounds and the coal age was at an end.

The strata, in the process of sinking, naturally became compressed, and folded up into immense wrinkles. In England two great folds were formed, more or less at right angles to each other on the surface of the land, the one lying from East to West and the other from North to South, the newly deposited coal measures naturally following the contour of these wrinkles.

These folds on the earth's surface were finally traced by Godwin-Austin, a geologist who may be called the discoverer of Kent coal, and who was the first to enunciate the theory that the present formation of the surface of the ground corresponds very nearly to the folds in the strata beneath ; thus a wrinkle formed in the coal age would assert itself in the form of a mountain chain to-day. In this manner Godwin-Austin traced the wrinkle running East and West across England,along the southern counties, leaving England at Folkestone and entering France at Cape Gris-Nez, where it joins the hills of Artois in the Pas de Calais. This chain has a most important bearing on the Kent coalfield and is called the Axis of Artois.

As the ground sank very slowly, the strata which we now call the coal measures were fairly close to the surface on the tops of the folds ; and as the latter became disintegrated by the action of wind, rain, frost, and other natural forces, the coal which laid on them was washed off and deposited in the valleys. The tops of the eminences from which the coal was washed are called anticlines, while the valleys below are called synclines and form the coalfield, containing as they do not only the coal originally deposited in them, but also that washed off the anticlines. This is a most important point, because if the anticlines can be traced, as was done by Godwin-Austin, it can be definitely stated where coal will *not* be found.

It is this anticline, the Axis of Artois, which bounds the southerly and westerly limits of the Kent coalfield, in fact, a fairly definite line can be drawn marking the end of the coalfield and the beginning of the anticline.

The vertical depth of the coal measures is limited in all directions by the bed of rocks called the Palæozoic floor, which is composed of very old rocks bearing the names "Devonian," "Cambrian" and the like, a nomenclature which generally refers to the district where the rock has its outcrop.

A great deal of time and money has been spent by the promoters of Kent coal, in getting an accurate survey of this floor. To this end numerous borings, each about 12ins. in diameter, have been driven all over the district until this floor has been reached ; it being useless to go deeper, because coal does not exist below this stratum. A sum of about £120,000 has been spent by one company on boring operations, and the survey is now nearly, if not quite, complete.

One result of these borings (which have been carried out in the greatest secrecy, sometimes even under police protection from trespassers), is that the company who had the foresight to sink so large an amount of money in unremunerative workings are now sure of the quality and extent of the whole coalfield, and have acquired the mineral rights of practically the whole coal-bearing area, extending to about 100 square miles, and have bought land in the positions most suitable for establishing collieries. The author ventures to believe that if the land-owners had been alive to the possibilities of Kent coal, instead of ridiculing the proposals put forward, they would not so easily have parted with their acres.

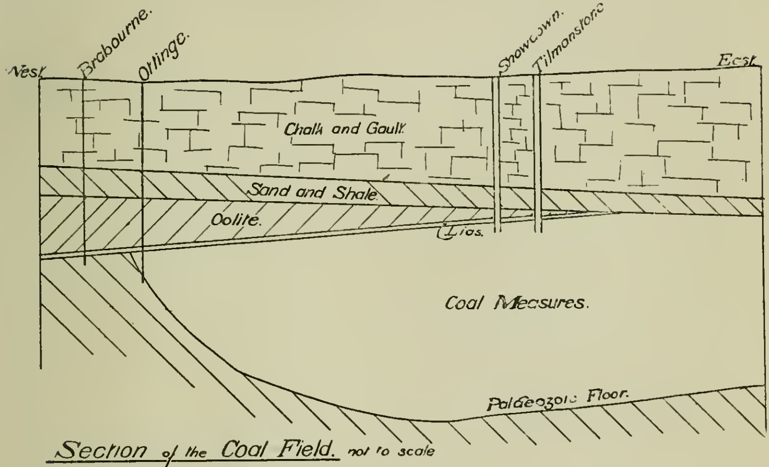

FIG. 2.

So far as can be ascertained, nearly thirty of these borings have been driven, most of them having proved the coal measures to underly the area, whilst others have been useful in mapping out the limits of the field with tolerable accuracy. All the borings towards the centre of the field have proved true coal measures at various depths. However, a boring at Ottinge towards the western edge of the coalfield passed through only a little broken coal, showing that locality to be near the anticline : while in a boring at Brabourne, still more to the west, the Palæozoic floor was cut without any coal being found, thus definitely establishing the anticline at that place and marking the western limit of the coalfield. The Palæozoic floor has been proved in a westerly direction as far as London, by borings put down for various purposes, having been reached beneath London itself at Streatham, Crossness and other places.

An average boring, anywhere near the centre of the coalfield passes through chalk for about the first 300ft. below Ordnance Datum. The thickness of chalk from the surface has been found to be over 800ft. in some places, and this formation is succeeded by gault, sandstone, clay and shale about 140ft. thick, with an underlying bed of oolites about 500ft. in thickness, separated from the coal measures by a thin junction bed of sand.

The chalk is good ground in which to sink shafts, but there is always the possibility, which cannot be guarded against, of meeting with fissures containing water which give trouble before they can be pumped dry. These fissures are found where they might be least expected and their presence has caused loss of life in the Kentish pits.

The sands and shales are troublesome to sink through, and the workings have often had to be temporarily abandoned at this point, pending the arrival of more powerful pumps, but little more trouble is expected from them now, because it was found that by installing pumps of sufficient capacity in a single pit the water could be drawn to that point from the whole area. The oolites are fairly good ground for shaft sinking when they are not too thick, and a study of the section of the ground will show that these rocks get very thick to the west of the coalfield ; for this reason it is not likely that pits will be sunk much further west than they are at present.

It is chiefly in the oolite rocks that iron is found in Kent ; there is estimated to be a large amount of iron, but unfortunately an analysis has shown the ore to contain sulphur, an ingredient which very largely detracts from the value of the deposit. It remains for someone of the mental calibre of Gilchrist Thomas to find an economical means of eliminating the sulphur and thus to ensure that Kent shall become not only a coal producing county, but also a centre for the multitudinous industries connected with iron. An analysis of the iron ore indicates that it contains about 40% of iron, the loss on calcination being about 18% leaving about 50% of iron in the calcined ore.

The coal measures themselves contain seams of coal and fireclay, besides other materials of no value which pass under the name of bind.

The coal seams vary in thickness from 13ft. 8in. downward, some of the smaller seams being unworkable. The aggregate thickness of coal is about 350ft., each seam having an average thickness of about 3ft., seams less than one foot thick not being included in the total. The coal on analysis is found to vary considerably in quality, some deposits being deemed to be harder than Welsh steam coal and possessing the properties necessary for marine work, whilst others are very soft, particularly (as is natural) in the upper seams. The author has seen coal from the upper seams which was so soft that it could be broken in the hand and crumbled to dust.

A small quantity of the coal from the upper seams has been taken from the Dover pits, and tried by the South Eastern Railway and other steam users in Kent ; but it was found to be too soft for steam raising, not being a genuine steam coal. A locomotive driver described the sample as a fairish coal, of average quality. Experiments of this kind are a mistake, being certain to give a false impression of the value of the coal field, and it would be better to wait until the lower seams are worked before a comparative trial of the coal deposits is attempted.

The beds of fireclay in Kent are of two kinds, one which is deposited in seams averaging four feet thick, found below every seam of coal in the coal measures, which undoubtedly was originally the actual soil of the primæval coal forest ; and another which comes from the gault formation and is worked near Ashford, outside the coal bearing area. The former, that is the clay from the coal measures, has been used for making the finest kinds of pottery, while the latter is suitable for fire-bricks, chimney pots, etc., and is only mentioned here because the industry is controlled by one of the coal companies, who acquired it in order to get good and cheap bricks for shaft lining.

The history of the South Eastern coalfield goes back only some forty years, but has involved the expenditure of much labour and capital and has more than once given an excuse for captious criticism of the men who have built up the industry.

About 1872, a boring was put down in the Weald of Sussex, with a view to discovering coal and for the purpose of proving the theory enunciated by Godwin-Austin with regard to the direction of the Axis of Artois before mentioned. The money for this venture was partly found by the Government, the remainder being subscribed by leading men of science, including the late Charles Darwin and the late Sir Henry Bessemer. The boring was a failure as far as coal was concerned, and it was abandoned at a depth of 1,900 feet, not having reached either the coal measures or the Axis of Artois. A report was subsequently drawn up recommending that a trial be made in Kent a little to the South of Canterbury. No money was forthcoming to make this trial, which would undoubtedly have been successful.

Nothing was done then until 1890, at which time the Channel Tunnel was being driven from the English side under the direction of the late Sir Edward Watkin. After the tunnel had been driven about a mile and a half, its further progress was vetoed by the Government, but Sir Edward Watkin, believing that the veto would shortly be removed, and not wishing to dismiss his staff, kept them employed in driving the now famous Watkin-Brady boring which after four years' work attained a depth of 2,200 feet and passed through eight workable seams of coal.

This sensational discovery, which positively proved the existence of coal in Kent, naturally aroused great interest, and a Mansion House meeting was held to decide upon the best means of profiting by the find. A company was formed to mine the coal, but unfortunately the site chosen for the pits, just below Shakespeare's Cliff, a little to the west of Dover, was not a good place in which to sink a shaft, on account of the great thickness of water-bearing strata between the chalk and the coal measures.

Work was proceeded with on this site at great expense, accompanied on one occasion by loss of life, due to a sudden inrush of water, the result being that the company working the mine were on several occasions in liquidation and the pits themselves were drowned, but fresh capital was subscribed, the company was reconstructed and the undertaking is now in a stronger position than before.

Until six or eight years ago the company referred to was the only one working coal in Kent. In 1904 another company was formed and started work by putting down the numerous borings mentioned earlier in this paper. The first results of these borings were so satisfactory that the company felt justified in starting two collieries of two shafts each. The first shafts sunk were about seven feet in diameter, and had been carried down about 300ft. when fresh discoveries at the borings caused the promoters to enlarge their plans, some of the shafts being abandoned and the others increased to eighteen feet in diameter.

Since that time the Kentish coal companies have never looked back but have worked on steadily in spite of considerable opposition, have sunk shafts of large diameter to great depths, through formations which before had never been touched by a miner's pick, and have carried out other works. The older shafts have progressed but slowly, while the later enterprises have profited by the experience of others in the past and the new shafts have been sunk at a speed which by comparison is almost incredible. In one instance a shaft nineteen feet in diameter was sunk to a depth of 1,100ft. in twenty months through the same formations in which a slightly smaller shaft had previously taken three years to sink.

The present works are mainly controlled by two companies, the Kent Collieries, Ltd., and the Kent Coal Concessions, Ltd. Another important company is the Anglo-Westphalian Company, operating mainly in the North East of Kent, and said to be financed in part by the German Imperial Government.

The Kent Collieries, Ltd., controls the pits at Dover on the site of the old Channel Tunnel Works and possesses mineral rights over an area of about two square miles ; the Kent Coal Concessions owns the mineral rights under practically all the remainder of the coal field, an extent of about 100 square miles, and is the parent company of about a dozen subsidiary companies which are sinking borings and working collieries, light railways and electric power stations in the district.

The oldest colliery is that at Dover already referred to, which works the pits started twenty-three years ago. These pits have been worked spasmodically during the interval and are now winding a little coal. The delays in sinking have been caused chiefly by want of money, but time has also been lost through the flooding of the pits. The last reconstruction of this company took place about five years ago and it is now said to be in the hands of northern mining experts and engineers, Sir William Armstrong being mentioned in this connection.

One shaft at least has reached a depth of 1,600ft., has passed all the dangerous spots, and is now in the coal measures, having passed through several workable seams of coal, fire-clay and iron ore. A little coal has been brought to the bank and used, but this is not the best, because it is obtained from the upper seams, which are always of an inferior quality.

Some years ago several lives were lost in these pits through an inrush of water, due to the sinking of a pit close to one which had been abandoned and contained a depth of 200ft. of water. The water burst through the floor of the new pit, in which thirteen men were working, and overwhelmed eight of them. Mention is made of this incident merely to illustrate the danger of working close to abandoned mines.

There is but little chance that this colliery will ever be able to handle a large output, for although its position within a stone's throw of the sea and the railway affords admirable facilities for transport, the works are so shut in by the high cliffs of Dover as to leave little room for surface equipment.

The other established collieries, six in number, belong to the Kent Coal Concessions group of companies ; the most advanced of these are Tilmanstone and Snowdown mines, both of which are now being sunk through the coal measures.

At Tilmanstone there are three shafts, 18ft., 19ft., and 14ft. in diameter, respectively. The exact depth of these shafts is kept a close secret, but two of them are known to be passing through the coal measures, and are therefore certain to be more than 1,200ft. in depth. Two of the shafts are still worked by the comparatively small sinking engines, which will probably be replaced when the coal is reached, while the third has recently been fitted with permanent winding engines and steel latticework head gear. The engine at this latter shaft is of first class construction and has two cylinders of about 30in. diameter, the steam admission being through drop valves, and the exhaust through Corliss valves ; while an overwind preventer, steam-brakes and steam reversing gear are provided.

The most interesting part of the equipment at Tilmanstone is the electrical pumping installation, necessitated by the difficulty experienced in sinking through the water-bearing strata, which in places is of the consistency of treacle. The installation consists of two horizontal sets erected in an underground pump house at the 900ft. level, and two vertical sinking sets which are slung in the shaft in a double purchase from capstans on the surface ; one of these pumps can be at work, while the other is lowered and reconnected. The sinking sets throw the water to the fixed sets which raise it to the surface. Electrical energy is supplied to these pumps at a pressure of 3,000 volts by means of two similar generators driven by Westinghouse steam turbines.

These pumps have worked continuously for about five months and have drained the water contained in the Greensand strata from beneath the whole district. The draining away of this water has been of the greatest advantage to the other collieries, in fact the Snowdown shaft was sunk in thirty days through the same strata in which that at Tilmanstone had taken nearly three years to sink.

The Snowdown Colliery has three shafts, two of 18ft. diameter and one of 19ft. diameter. No. 1 shaft (18ft.) is now abandoned on account of an underground stream of water having been encountered in the chalk at a depth of 275ft. The other two shafts sunk within 100 yards of the former did not meet with any water at that level. Very little pumping of any kind has been done at Snowdown because the water which in the ordinary course would have been found there has been drawn off at Tilmanstone. The equipment at Snowdown is very similar to that at Tilmanstone, except for the fact that steam driven, instead of electrically driven pumps are used in the pits, the result being that the atmosphere below ground at Snowdown is very hot. It is now proposed to work the Snowdown plant electrically and an order has been applied for by the company to erect an overhead conductor from Tilmanstone to Snowdown for this purpose.

The Snowdown Colliery was the first mine of the Kent Concessions Company from which coal was raised. This important event took place on November 19th last, when the pits passed through an 18in. seam of excellent coal at a depth of 1,370ft., but sinking is being continued in order to reach the 4ft. 4in. seam of house and gas coal and the 6ft. seam of steam coal, which lie about 60ft. deeper.

The principal item of interest at Snowdown is a ferro-concrete chimney, which was put up about six years ago ; it is some 200ft. high, and has a maximum diameter of about 8ft. Soon after this chimney was erected it developed a distinct bend, and later a number of cracks appeared, a symptom which led to its being strengthened with iron bands. It is now entirely condemned and will shortly be felled ; a brick shaft being in course of construction to take its place.

Of the other established collieries, one has three shafts carried down a considerable distance, and will, it is expected, be winding coal in May, 1913. There are three other collieries the shafts of which are as yet hardly below ground.

All the shafts at these mines are lined, in ordinary strata, with bricks, the brickwork being supported on cast iron curb-rings every 40 to 60ft. in depth according to the nature of the ground. Where much water has been encountered the shafts have been lined with cast iron tubbing, built in segments similar to bridge piers, the joints between the segments being made with lead foil.

An important feature of the Kent Coal enterprise is the network of light railways which has been planned and is already partly carried out to connect the mines to the sea, to one another and to the South Eastern and Chatham Railway main lines.

These railways are very rough in construction, but are intended to be improved so as to be suitable for carrying passengers and farm produce as well as the minerals for which they are chiefly being constructed. The lines have little cutting or embankment, all roads being crossed on the level and the gradients in some places being very severe. Flange rails are used and are bolted to half round transverse sleepers. The construction of the lines was necessitated by the damage done to the roads by traction engine traffic, which was naturally very heavy on the roads leading from the mines to the main railway lines. It is strange that the Kent County Council, instead of encouraging the extra traffic due to the mines, which tended to increase the prosperity of the county, exacted payment from the company to the extent of about £30,000 for damage to the roads. Possibly this is the approved way of encouraging a new industry !

In future it has been decided to build a light railway to the site of a new colliery before beginning to sink a shaft and thus to avoid all road borne traffic.

The course of this important enterprise has now been traced from its conception in the minds of scientists to its present state of development. It has passed through many vicissitudes on the way. Opposition has of course been fairly plentiful, but has been based chiefly on prejudice due in part to the unfortunate financial history of the earlier undertakings. But, to the author's mind, the greatest obstacle which has had to be overcome has been the apathy of the County of Kent itself to the scheme which has been developed within its boundaries and which promises to revolutionize the countryside. However, the scheme is now on the eve of maturity and will, it is hoped, meet with unqualified success and even take its place among the premier industries of the kingdom.

February 3rd, 1913.

ORDINARY MEETING.

Induction of the President.

Mr. John Kennedy, the retiring President, introduced the new President, Mr. A. Valon, whom he invested with the Presidential badge and presented with a certificate of election.

The **President,** on taking the chair, said that the first duty that he had to perform was one which he should discharge with very great pleasure. It was to propose a vote of thanks to the retiring President. Mr. Kennedy's services to the Society were so well known that it was unnecessary to pronounce any eulogy of his work. Since the incorporation of the two former societies into one body the activities of the incorporated society had extended in several new directions, and this had caused a great deal of extra work to devolve upon the President. None of them knew how much time and energy Mr. Kennedy had devoted to his duties. As one who had worked with Mr. Kennedy, he had much pleasure in proposing a very hearty vote of thanks to him for his services during the past year

Mr. H. C. H. Shenton seconded the motion. As one who had served on the Council under Mr. Kennedy, he had had ample opportunity of observing how Mr. Kennedy devoted himself to the interests of the Society. All who had come into contact with him were under great obligations to him for his kindness and for the way in which he had dealt with every question which had come before him.

The motion was carried with acclamation.

Mr. Kennedy thanked the meeting for their kind expression of thanks. His work during the year had been very much a labour of love. He could not vacate the chair without thanking the members of the Council for the sympathy with which they had assisted him on every occasion. Fortunately, the Society had been very prosperous during his term of office, and he hoped that it would continue to prosper as it deserved to do.

The **President** then called upon Mr. Wm. Yorath Lewis to read the following paper :—

THE BUS *v.* TRAM CONTROVERSY,

AND OTHER ASPECTS OF THE LONDON TRAFFIC PROBLEM.

By Wm. Yorath Lewis, A.M.I.Mech.E., A.M.I.E.E.,
M.Am.Soc.Mech.E.

Do Londoners—patronising trams and 'buses to the extent of probably 14 hundred million rides this year, at a cost of quite £7,000,000—appreciate the importance of the London Traffic Problem? Does the community adequately realise that the cost of living, and, in fact, everything comprising each individual's welfare, is primarily dependent on transport? Whilst it is easy to raise questions, it is often difficult to answer them. These questions, however, need no sage to discern that their answer must be in the negative, since, as regards transport, one may look in vain for any indication that Londoners as a community are even beginning to wake up.

There is no sign of concerted study and action, except on the part of those monopolists who are out to kill two birds with one stone, *i.e.*, to play the part of public philanthropists and at the same time to make more money. Whether such a feat is within the bounds of possibility is a debatable question. It is certainly reasonable that judicious capital expenditure should be entitled to a fair return, but what about inflated capitalisation? Should not the Government when granting monopolies take such steps as would minimise the inflation of capitalization? Indeed, one might further ask, should not the Government, in order to ensure the lowest possible fare ratings, see to it that there be no injudicious expenditure either in initial outlay or in operating costs? Such questions, and other pertinent ones that can only be answered in the affirmative, indicate that at least the Governments of the past did not see far enough ahead.

The London Press devotes much space and even leading articles to the traffic question. But is not its interest preponderatingly on the monopolist side? Every editor knows well that any news concerning London traffic arouses the Londoner's interest more than anything else. On the other hand, the public relies to a great extent upon the power of the Press to guard its interests. Yet even the Press accomplishes but little towards the solution of London's greatest problem, viz., that of her traffic. The reason is not far to seek. The Press, anxious and willing though it may be, has had nothing much to report beyond the operations of the "Traffic Trust" and the effect of its 'buses. How vast and valuable would be its aid if only it were enabled to disseminate the findings of a body of capable investigators devoted to the study of the problem in all its aspects and ramifications! It is, of course, well known that no such body exists, though many have been the demands for a Traffic Board. As to this, the latest suggestion comes, not unnaturally, from Sir Edgar Speyer, M.P., the head of what (perhaps erroneously) is called "The Traffic Trust," who advocates that "such an authority should be an owning authority."

In this connection attention might well be directed to an article in the *Daily Chronicle* of October 28th last, emanating from "a high authority in matters connected with the transit question," forecasting the acquisition of London's local railways by a Traffic Board constituted on the lines of Metropolitan Water Board. The suggestion, coming through such a medium, presumably has considerable weight behind it, and, curiously enough, it has been received with an ominous silence. Is it that the Dock and Water Boards established by the Government have been such blessings that the example is to be followed in the case of traffic? Is it that London gives consent by silence? Sir Edgar Speyer and his immediate associates are well known to be supporters of the present Government, but in their recent operations, involving so many important amalgamations, it is not difficult to recognise the impelling force of associates*, who have had considerable experience in American Traffic Trust methods. Probably, therefore, the parties have planned independently to get into such a position as will enable the group to dictate their own terms when the question of nationalisation arises. They are, it seems, to go to the L.C.C. in due course, saying, "Here is the most perfect (*sic*) system of "railways and tramways serving completely (*sic*) the greatest "city in the world with an organisation of the finest character, "with good receipts and still greater prospects. Will you buy "it? The spade work has been done; why not become the "monopolist yourself?"

The proposition would, no doubt, be a very interesting one, but one may ask, Is it essential to railway nationalisation, which many consider urgently deserves most serious attention, that powerful financial groups should so considerately perform such spade work? The suggestion is put forward as affording a preliminary test of railway nationalisation, but whether the experiment would prove a valid test of that great step appears to be open to grave doubt. The Traffic Trust's facilities comprise means of transport other than railways, and they by no means handle all the passenger traffic, nor do they touch the equally important freight traffic. Whilst, however, a Traffic Board, constituted of *all* owners engaged in the carrying trade (both passenger and freight) and established on the lines of the Metropolitan Water Board, may deserve consideration, should not the patrons and the workers also be represented ? As to a Board constituted on the lines recommended by the Royal Commission, that tribunal is nowadays more than ever manifestly impossible, at least until the government of London be reformed beyond recognition. The Imperial Government is not likely to derive much encouragement in this direction from the experimental London Traffic Branch of the Board of Trade.*

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*Notably Mr. Albert Stanley, the managing director of the combine.

What, then, can be done to give the Press such matter relating to the subject as will enable it more effectively to exercise its influence in the true interest of the community ? There is plenty of need of an educational campaign. The problem is abundantly full of points awaiting analysis and publicity. The existing conditions cannot be considered as in every way satisfactory. Doubtless there exists a great deal of pent up discontent which would be illuminating if it could find relief in expression. Doubtless, too, those who travel to and fro know something of what they require. Is it advisable that Londoners should remain passive during these critical times ? Should they not awaken to the reality that very powerful forces are being brought into action, possibly not in their interest nor for their welfare ?

It is greatly to be regretted that the London Traffic Problem has become a political question, though it is difficult to imagine how this could have been prevented under the existing system of conducting public affairs. Londoners would, however, do well to insist upon greater attention and less biased consideration being given to the traffic problem, since it is unquestionably a matter of vital interest both to classes and masses. Cheap and effectively rapid transit is the life blood of trade and the raw material of industry. It is the key to prosperity, the breath of modern life. Political differences upon matters often really of but little moment, and always insignificant in comparison with this widespread and far-reaching necessity, should therefore be sunk in a united effort for its attainment. Why, then, should there not arise a London Transport Association† for the purpose of studying the situation, educating the public, and working in all directions towards the goal of cheap transport ? Such an institution would soon become a powerful factor in London's development, and might effectively take the place of variously suggested Traffic Boards. Its income, at only one penny per annum per traveller,* would be about £30,000 a year, and since good service could be also rendered to all concerned with London freight traffic, small contributions from traders might easily swell the income to £50,000 a year. Such funds would enable a skilful staff of paid officers to be set at work in numerous directions urgently needing public scrutiny and elucidation. The constitution of such an Association might possibly be founded upon an electoral basis, the Council and its officers being an elected body. Thus the Referendum and Proportional Representation system of voting might be put to practical test, every Londoner registering his name and address being entitled to vote.

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* The last report of this department was issued in December, 1911, and dealt with 1910 records, in a manner regrettably biased in favour of motor 'buses. The report dealing with 1911 returns has not yet been issued.

† The recently formed "London Society" will doubtless make an effort to deal with the traffic problem, but its constitution is such that Londoners cannot expect much real assistance from that body, commendable though its objects are. On the other hand a London Traffic Association could greatly assist the London Society.

It may be wondered why the County Council does not more adequately reflect the opinion and guard the interests of the public upon this all-important question of transport. In the first place it should be noted that there are only about three-quarters of a million of electors on the London County Council registers. Further, that the number of electors who take the trouble to vote is less than 55% of the registered number. Thus the aspirations of London's many million travellers cannot be considered as adequately represented by successful candidates at the L.C.C. elections, especially as only a small proportion serve on the Improvements Committee which deals with street traffic. Moreover, as regards transport, the Council deals only with its tramway undertaking, which is baulked in every direction by the veto of 28 local Borough Councils. These are even less representative of the public, and (in the opinion of many people) like the County Council itself, manage to look after private and party interests better than those of the public in a large number of matters, among which the tramway undertaking by no means receives the attention it demands. The policy of the present Council is admittedly opposed to municipal trading in any form, so that the tramway enterprise hardly receives fair play. The consequent action of the Council cannot but be severely censured as a glaring act of disloyalty to London, whose electors, subsequently supported by the strongest recommendations of the Royal Commission, deliberately decided for municipal trading in passenger transport by means of tramways. Consequently a comprehensive system designed to cover and interconnect the whole of London was forthwith embarked upon—which, with the exception of certain all-important interconnecting links, was practically completed some years ago. Naturally, it was reasoned that the success of London's tramway undertaking would be greatly augmented by the lucrative short-haul traffic, which its interconnections through the central area would ensure. Why, then, have these essential finishing touches been so persistently baulked? Has London decided to abandon municipal trading, to throttle its trams, to jeopardise £12,000,000, "to spoil the ship for a ha'porth of tar"? Surely not, for even if 'buses are superior to trams, it would be nothing short of rank folly to jeopardise the £12,000,000 municipal undertaking which has admittedly already proved an incalculable benefit to London.

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* The average amount now spent per head of population in 'bus and tram journeys about London is approximately £1 per annum.

Let us briefly review what has been going on. A 'bus *v.* tram controversy has been hotly pursued in the newspapers but this has been more in the nature of an attack on the trams than a fair debate. In fact, it has clearly been an organised attempt on the part of motor enthusiasts and 'bus interests, through various organisations, backed by their friends in the trade Press and in political quarters, to protect the 'bus monopoly in the central area, and to excuse the robbery from the tramway undertaking of traffic which the latter has legitimately developed in the suburbs. This warfare has been conducted on the assumption that the motor 'bus possesses superlative advantages over the electric tram, and that these advantages warrant the arrest of further tramway extensions, if not the extinction of tramways at a not far distant date.* To this end untrue and ridiculous statements have abounded in many of the newspapers.

Whilst it must be acknowledged that a few members of the London County Council have endeavoured to support the trams by refuting several wild statements that emanated from 'bus enthusiasts, much more might easily have been done in this direction. Why has not the Tramway Department† of the L.C.C. done at least something to combat the tide of misrepresentation designed to divert popularity from the trams to the rival 'buses? Is it not because it has been bound to lie low in deference to the prevailing policy of the Council? There must be some such reason for its significant inaction and silence. Even at the recent Congress of the Municipal Tramway Association at West Ham its contribution to the controversy was restricted merely to a brief expression to the effect that tramway men were not afraid of 'bus competition. Whilst this may truly represent the complacent attitude of municipal tramwaymen in the provinces, it can hardly be the proper attitude for London's Tramway Department, because it circumstances are entirely different. London is surely entitled to expect from its Tramway Department that direction and guidance, with the same aggressive spirit of progress and activity, which Glasgow and Leeds get from theirs—irrespective of the party in control of the Council.

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* See Lord Montagu's evidence before the London Street Traffic Inquiry, week ending, January 18th, 1913, and his paper on "Tram projects for London" in the R.A.C. Journal.

† Apparently the L.C.C. Tramway Department does not comprise a publicity or advertising department. At any rate, if it does it has missed a good chance of popularising the service, a chance which the 'bus concern has utilised to the full on behalf of its 'buses.

Looking further afield, the subject does not appear to have been adequately debated before any technical society. However, at the Congress of the Tramway and Light Railway Association, held at Swansea last summer, a paper was read by Mr, Pott, the Chief Engineer of the Metropolitan Electric Tramways, entitled, " The respective values of Tramways, Motor 'Buses and Railless Traction as means of transport." As a further illustration of the subtle nature of the forces at work, this paper is extremely interesting, but let us now consider the paper and the discussion which followed its delivery. With due deference to its author and those who discussed his paper, one may search it in vain for a really useful comparison of the merits of trams and 'buses in regard to their relative capability of meeting the requirements of any one of London's many differing traffic problems. Mr. Pott sets out correctly enough : " To consider " the merits and demerits of each system ; to decide which is " most suitable for any particular district ; and to discover " which vehicle is best for public service under present con- " ditions."

None of these worthy objects is, however, attained. No particular case in point is investigated ; a futile attempt is made to set up comparisons on the ill-founded basis of cost per vehicle mile, taking vehicles of widely differing seating capacities operated on the same time service. It is not surprising, therefore, that the conclusions drawn at the end of the paper comprise such vague generalizations as " Tramways are the best means of carrying cheaply numbers of people along the streets." " Motor 'buses are most suited to towns where roads are narrow or not straight, and where, for these reasons, vehicular congestion is great." The lessons which the paper was intended to teach were that " 'there " is still room for all ' yet that ' there is seldom room for two on " the same road,' and then ' only when worked in harmony ' ; that " ' the public almost always benefits by competition,' yet that " ' rate cutting is an absurd practice ' ; that ' whilst co-ordination " of traffic facilities is everywhere desirable, this does not mean " so much a grouping of financial interests ' ; and that ' there is " imperative need for a wholesale amendment of the laws con- " trolling tramway construction and operation.' As to the latter a list of objectionable clauses in the Tramways Act of 1870 is given in an appendix, with comments indicating that new legislation should ensure the welfare of privately owned tramways.

Whilst the paper superficially appears to be a fair consideration of the relative merits of trams and 'buses, it certainly comprises a most inadequate and unfair comparison, if, indeed, it can be considered a comparison at all. It is not difficult to detect a disinclination to reveal the true value of motor 'buses as a means of transport in public service, in respect of the London Traffic Problem. Evidently its author deemed it wise to say nothing regarding 'buses which might in any way affect the continuance of the exceptionally favourable conditions under which they are allowed to operate in London. 'Buses were somewhat superciliously welcomed as useful feeders and auxiliaries to tramways in outlying districts, though for this class of work the consensus of opinion at the Congress favoured railless traction. It is a pity that the paper and others delivered before the Swansea Congress and those given at the subsequent Congress of the M.T.A. did not throw some light on the London 'bus *v.* tram controversy. The great question is not whether 'buses are or are not the better for service in the outer suburbs. What London wants to know is whether they are really so beneficial and advantageous in the central area as their supporters try to make out.

Let us, therefore, investigate the matter with the object of arriving at a fair and reasonable conclusion as to whether trams or 'buses offer on the whole the better facilities for passenger transportation in London. The London traffic problem is most acute in the central area, and this is true of the traffic question in most great cities, since all have a business quarter wherein the density of traffic is almost intolerable during business hours. In most towns and superlatively in London this important section is entirely surrounded by suburbs. In some other cities it is only partially so surrounded, but nevertheless, practically the same conditions apply to all. Confining the consideration more especially to the requirements of the surface traffic, these conditions arise from (*a*) the preponderating exceptionally "short-haul" traffic within the central area; (*b*) the "increased-length haul" traffic to and from, in and between the central area and districts immediately outside thereof; (*c*) the comparatively "long-haul" traffic to and from points further afield; (*d*) the through or interconnecting traffic between neighbouring fringe boroughs and those across the central area. (*a*) and (*b*) are by far the most important, (*c*) is chiefly handled by sub-surface facilities, and (*d*) so far as surface traffic is concerned is largely more imaginary than actual. Both surface and subsurface facilities contribute, in conjunction with main line railways, to handle the heavy morning and evening traffic which

LIST OF SERVICES.

1 TOWER BRIDGE — WELSH HARP.
[illegible] | 4 am – 10 pm; [illegible] – 11.54 pm†; 6.0 am‡ – 7.48 am‡; 9.30 am – 10 pm; 10.18 pm† – 11.3 pm† | Every 5 min
Via [illegible] Bridge, Charing X, Tottenham Court [illegible] Rd, Kilburn, [illegible] Cricklewood. [illegible] From Tower Bridge Rd [illegible] Hill only
NOTE On [illegible] and Sundays this Service is extended to Edgware [illegible] Avenue for the Flying Ground, Hendon

2 FINCHLEY RD. — EBURY BRIDGE.
[illegible] pm | 7.30 am – 11.30 pm | Every 4 min
[illegible] pm | 9 am – 11.15 pm | Every 4 5 min
[illegible] Marble Arch, Park Lane, Hyde Park [illegible] Station

3 BRIXTON — CAMDEN TOWN.
[illegible] – 11.30 pm | 7.21 am – 11.24 pm | Every 5 min
[illegible] Rd, Westminster Bridge, Charing [illegible] Regent's Park, Albany St
NOTE This Service does not run on Sundays. See No. 59

4 FINSBURY PARK — ELEPHANT & CASTLE.
[illegible] – 11.[illegible] pm | 7.[illegible] am – 11.37 pm | Every [illegible] min
[illegible] – 11.3[illegible] pm | 9.[illegible] am – 11.30 pm | Every 6 min
[illegible] Highbury Barn, Highbury Station, Upper St, Angel, [illegible] Rd, Aldersgate St, St Paul's, Ludgate Circus, Black[illegible]

5 PUTNEY — STROUD GREEN
[illegible] am – [illegible] pm | 7 am – 12 midn't. | Every 4 5 min

WIMBLEDON — STROUD GREEN
[illegible] pm; [illegible] am*; [illegible] – 11.25 pm* | 8.45 am – 8.20 pm; 8.30 pm† – 11.27 pm† | Every 12 min
[illegible] Brompton Rd, Piccadilly, Shaftesbury Ave., [illegible] Caledonian Rd, Nag's Head, Seven Sisters Rd. [illegible] † To [illegible] only.

6 KENSAL RISE — SHOREDITCH.
[illegible] 7 am – 10.[illegible] pm | 8.0 am – 11.[illegible] pm | Every 6 min

KENSAL RISE — CHARING CROSS.
[illegible] – [illegible] pm; 11.40 pm* – 11.[illegible] pm* | 10.9 am – 11.14 pm | Every 7 min.
[illegible] Kilburn, Edgware Rd, Marble Arch, Piccadilly [illegible] Cross, Strand, St Paul's Churchyard, Bank, Liverpool St. * Oxford Circus only

7 LIVERPOOL ST. — WORMWOOD SCRUBS.
[illegible] 8 am – 1[illegible] am | 7 am – 11.3[illegible] pm | Every
[illegible] am – [illegible].47 pm | 9.30 am – 10.5[illegible] pm | 4-5 min
Via Bank, G.P.O., Holborn, Oxford St, Marble Arch, Paddington (G.W.R.), [illegible] Grove, Richmond Rd, Westbourne Park, Cornwall Rd, St [illegible]

8 WILLESDEN (White Horse) — OLD FORD.
[illegible] am – [illegible].50 pm; 8.30 am* – [illegible] am* | 6.30 am – 11.28 pm | Every 4 min
Sundays [illegible] am – 11.[illegible] pm | 9 am – 1[illegible] pm; 10.10 pm† – 11.36 pm†
Via [illegible] Willesden Lane, High Rd, Kilburn, Maida Vale, Marble [illegible] Oxford St, Holborn, G.P.O., Bank, Liverpool St, Shoreditch, [illegible] Rd, [illegible] Rd. * To Kilburn only † To Bank only

9 LIVERPOOL ST. — BARNES.
Weekdays [illegible] – 11.4[illegible] pm | 5.50 am – 12 midnight | Every 5 min
Sundays [illegible] am – 11 [illegible] pm | [illegible] – 11.[illegible] pm | [illegible]
Via Bank, St Paul's, Strand, Charing X, Piccadilly Cir., Hyde Pk Corner, Kensington, Hammersmith, [illegible]

10 ELEPHANT & CASTLE — WANSTEAD.
Weekdays [illegible] am – 10.[illegible] pm; 10.[illegible] pm* – [illegible] am* | [illegible] am – 10 [illegible] pm; 10.51 pm* – 11.51 pm* | Every 5 6 min
Sundays [illegible] am – 10.[illegible] pm; 10.10 pm* – 12.20 am* | 10.20 am – 11.1[illegible] pm; 9.10 am† – 10.50 am†; 11.2 pm† – 12 midn't†
Via Newington, Borough, London Bridge, Fenchurch St, Whitechapel Rd, Stratford, Leytonstone High Rd., Cambridge Park
* To Stratford only † From Stratford only.

11 LIVERPOOL ST. — HAMMERSMITH.
Weekdays 7 [illegible] am – 1[illegible].12 am | 6.8 am – 11.8 pm | Every 2 3 min

LIVERPOOL ST. — SHEPHERD'S BUSH.
Sundays [illegible] am – 12 midnight | 8 am – 10.48 pm | Every 4 min
Via Bank, Strand, Charing Cross, Westminster, Victoria Stn, Sloane Square, Chelsea, Walham Green, [illegible] Palace Rd.

12 TURNHAM GREEN — PECKHAM RYE.
Weekdays 7.50 am – 11.14 pm | 7.36 am – 11.21 pm; 11.25 pm* – 12.30 am* | Every 4 5 min
Sundays [illegible] am – [illegible] pm | 9 am – 9.40 pm | Sundays every 7 8 min
[illegible] Hill Gate, Marble Arch, Oxford Circus, [illegible] Cross, Westminster Bridge, Elephant & Castle, Camberwell Green.
NOTE — This Service is run in conjunction with Messrs Thos Tilling, Ltd., Peckham. * To Oxford Circus only.

13 LONDON BRIDGE STN. — HENDON (The Bell)
Weekdays [illegible] am – 10.[illegible] pm; 10.[illegible] pm* – 12.4 am* | 7 am – 10.50 pm; 10.[illegible] pm* – 12 midn't.* | Every 4 min.

Sundays only CHARING CROSS — HENDON.
10.[illegible] am – 10.18 pm; 10.23 pm* – 11.40 pm* | 9.2[illegible] am – 10.4[illegible] pm; 10.5[illegible] pm* – 11.35 pm* | Every 4 5 min
Via London Bridge, Cannon St, St Paul's Churchyard, Strand, Charing X, Piccadilly Cir., Oxford Cir., Oxford St, Baker St, Finchley Rd, Child's Hill, Golders Green. * To Child's Hill only
NOTE. — On Saturday Afternoons and on Sundays a Special Service is run from Golder's Green Station to "The Greyhound" for the Flying Ground (See No. 83)

14 PUTNEY — HORNSEY RISE.
Weekdays 8.42 am – 11.56 pm | 6.[illegible] am – 12 midn't. | Every 5-6 min
Sundays 9.24 am – 11.24 pm; 8.41 am* – [illegible] am*; 11.3 pm† – 11.51 pm† | 9.[illegible] am – 1[illegible] pm; 10.42 pm† – 11.30 pm† | Every 6 min
Via same route as No. 5 to Nag's Head, thence Seven Sisters Rd, Hornsey Rd. * From Walham Green only. † To Walham Green only

15 PUTNEY COMMON — EAST HAM.
Weekdays 7.1[illegible] am – [illegible] pm; 10.3 pm* – 11.[illegible] pm* | 9.6 am – 11.52 pm; 6 am† – 9.16 am† | Every 4 5 min
Sundays 9.30 am* – 11.[illegible] pm* | [illegible] am† – 11.[illegible] pm†
See No. [illegible] to Piccadilly, thence Charing X, Strand, Bank, Aldgate, Commercial Rd., Plaistow. * To Plaistow † From Plaistow

16 VICTORIA STATION — CRICKLEWOOD.
Weekdays [illegible] | [illegible] | Every [illegible]
Sundays 9 [illegible] am – 1[illegible] pm | [illegible] – 12 midnight
Via Grosvenor Place, Hyde Park Corner, Marble Arch, Maida Vale, [illegible], Brondesbury

17 EALING BROADWAY — LONDON BRIDGE STA.
Weekdays [illegible] am – 11.[illegible] pm; 6.[illegible] am* – 7.[illegible] am* | 7.[illegible] am – 10.[illegible] pm; 10.[illegible] pm† – [illegible] | Every 4 min
Via Acton, Shepherd's Bush, Notting Hill Gate, Marble Arch, Oxford St, Holborn, G.P.O., Bank

Sundays only EALING — EAST HAM.
9.50 am – 1[illegible] pm; 9 am* – 9.[illegible] am*; 11.17 pm* – 11.[illegible] pm* | 9 am – [illegible].50 pm; 9.50 pm† – 11.10 pm† | Every 7 min
Via Acton, Shepherd's Bush, Notting Hill Gate, Marble Arch, Oxford St, Holborn, Bank, Aldgate, Commercial Rd
* From Acton. † To Acton only

18 WILLESDEN (White Hart) — LONDON BRIDGE STN.
Weekdays 7 am – 11.15 pm | 8.12 am – 12.28 [illegible] | [illegible]
Sundays 8.48 am – 10.4[illegible] pm | 10 am – 11.[illegible] pm | [illegible] min
Via Harlesden, Kensal Green, Harrow Rd, Edgware Rd, Euston Rd, King's Cross, Gray's Inn Rd, [illegible] St, Ludgate Hill, St Paul's, Cannon St.

19 CLAPHAM JUNCTION — HIGHBURY BARN.
Weekdays 6.40 am – 11.40 [illegible] | 7 [illegible] | Every 3 min
Sundays 9 am – 1[illegible] pm; 11.2 pm* – 11.20 pm* | 9 am – 1[illegible] pm
Via Clapham Junction, Battersea Bridge, Chelsea, Sloane St, [illegible] Shaftesbury Avenue, Bloomsbury, [illegible] Avenue, Angel, Islington, Highbury. * To Highbury Station only

20 SHEPHERD'S BUSH — WEST NORWOOD.
Weekdays 7 [illegible] am – 11.[illegible] pm | [illegible] | Every [illegible]
Sundays 8.4[illegible] am – 11.40 pm | [illegible] am – 11.4[illegible] pm
Via Notting Hill Gate, Marble Arch, Oxford St, [illegible] X, Westminster, Tate Gallery, Stockwell, Brixton, Herne Hill, [illegible]

21 WOODGREEN (Ashmonger's Arms) — GREENWICH
Weekdays 6.30 am – 10 pm; 10.8 pm* – 11.1[illegible] pm*; 6.30 am† – 7.[illegible] | 7.10 am – 1[illegible] pm; 6.40 am† – 7.[illegible] am† | Every [illegible]
Sundays [illegible] am – 1[illegible] pm; 10.2[illegible] pm* – 11.[illegible] | 10.1[illegible] – [illegible]; [illegible] – 10.7[illegible]
Via Harringay, Finsbury Park, Green Lanes, [illegible] Rd, [illegible] Bank, London Bridge, [illegible] Old Kent Rd, New Cross, Deptford.
* To "Lord Wellington" only. † From "Lord Wellington."

22 HOMERTON — PUTNEY.
Weekdays [illegible] am – 11.2[illegible] pm | 7.[illegible] – [illegible] pm; 10.[illegible] pm* – [illegible] pm* | Every 7 [illegible]
Via Hackney Station, Dalston, [illegible] Liverpool St, Bank, Holborn, Charing X, [illegible] Hyde Pk Corner, Sloane St, [illegible] Putney Bridge
* Leyton only
NOTE — This Service does not run on Sundays.

23 ACTON VALE — BARKING
Weekdays [illegible]

EALING — RIPPLESIDE.
[illegible]

24 PIMLICO — HAMPSTEAD HEATH
[illegible]

25 VICTORIA STATION — SEVEN KINGS.
Weekdays [illegible] pm* – 12[illegible]
Sundays [illegible] .24 pm* – 11.30 pm*
Via Grosvenor Place, Hyde Park Corner, [illegible] Holborn, G.P.O., Bank, Aldgate, [illegible]

26 WEST KILBURN — HACKNEY WICK.
[illegible]

27 TWICKENHAM STN. — HIGHBURY STN.
Weekdays 7.3 am – 11 [illegible]
[illegible]

28 WANDSWORTH BDGE. — CHILD'S HILL.
[illegible]

29 VICTORIA STATION — SOUTHGATE
Weekdays [illegible]; 11.[illegible] pm* – 1.[illegible] am* | [illegible] | Every 5
Sundays only **VICTORIA STATION — COCKFOSTERS.**
[illegible] Harringay, [illegible]

30 KING'S CROSS — PUTNEY
[illegible] am – 10.[illegible] pm; 11.10 pm* – [illegible] am* | 8.55 am – 11.9 pm; 7 am† – 9.4 am† | Every 4 5 min
Sundays [illegible] – 12 midnight* | 11.3 am – 10.[illegible] pm; 9 am† – 11.10 am†
Via [illegible] Oxford Circus, Oxford St, Park Lane [illegible] South Kensington, Old Brompton Rd [illegible] Putney Bridge.
* To Fulham Cross only. † From Fulham Cross.

31 CHELSEA — SWISS COTTAGE (St John's Wood)
7.19 am – 11.5 pm | 7.54 am – 10.29 pm; 0.34 pm* – 11.45 pm* | Every 5 min
Sundays [illegible] am – [illegible] pm | [illegible] am – 0.34 pm; 10.30 pm* – 12 mid.*
Via [illegible] Earl's Court Rd, Kensington, Church St, Notting Hill Gate, [illegible] Kilburn, Bridge Rd.
* To [illegible] of Wales, Harrow Road only.

32 CHARING CROSS — LADBROKE GROVE.
7.37 am – 12.45 am | 7 am – 12.0 am | Every 5 6 min
Via Piccadilly [illegible] Oxford Circus, Marble Arch, Edgware Rd, [illegible]
NOTE This Service does not run on Sundays.

33 LIVERPOOL ST. — EAST SHEEN (Black Horse)
[illegible] am – 11.20 pm | 7.52 am – 11.18 pm | Every 5-6 min

PICCADILLY CIRCUS — EAST SHEEN
[illegible] | [illegible] am – 11.7 pm
[illegible] route as No. 9 to Hammersmith, thence Barnes Common [illegible]

34 LIVERPOOL ST. — WEST NORWOOD.
[illegible] | 7 [illegible] – 11 pm | Every 5-6 min
[illegible] Elephant & Castle, [illegible]
NOTE This Service does not run on Sundays.

35 ELEPHANT & CASTLE — WALTHAMSTOW. (Chapel End)
[illegible] am – 10.4[illegible] pm; 10.[illegible] pm* – [illegible] am* | 7 am – 11.6 pm | Every 3 min
[illegible] St, Liverpool St, Shoreditch [illegible] Hackney, [illegible] Clapton, [illegible] Rd, to the Crooked Billet.

Sundays only **BRIXTON — CHINGFORD MOUNT.**
[illegible] – 8.[illegible] pm; [illegible] – 1[illegible] am* | [illegible] am – 10.[illegible] pm; 8.20 am† – 10.34 am† | Every 6 min
Via Brixton Rd, Kennington Park Rd, Elephant & Castle, etc., as above
* [illegible] † From Leyton

35A ELEPHANT & CASTLE — WALTHAMSTOW (Wood St)
Weekdays [illegible] am – 10.47 pm; 1[illegible] pm* – 12.18 am* | 7.8 am – 11.8 pm | Every 6 min
Sundays 1[illegible].0 am – 9.5 pm; 9.[illegible] pm† – 11.40 pm† | [illegible] pm – 10.[illegible] pm; [illegible] am‡ – 12.23 pm‡
Via [illegible] as 35 to Bell Corner, Hoe Street, thence Forest Road. [illegible] Duke's Head [illegible] † To Baker's Arms ‡ From Baker's Arms only

36 WEST KILBURN — CATFORD.
Weekdays 7 am – [illegible] pm; 10.3 pm* – 11.[illegible] pm* | [illegible] am – 10.9 pm; 10.1[illegible] pm† – 10.45 pm†; 1[illegible] pm‡ – 11.1[illegible] pm‡ | Every 5 min
Sunday [illegible] am – [illegible] pm; [illegible] pm* – 11 [illegible] pm* | 1[illegible].0 am – 11.[illegible] pm | Every 6 min
Via Walterton Rd, Harrow Rd, Paddington, Edgware Rd, Marble Arch, Park Lane, Hyde Park Corner, Victoria Station, Vauxhall Bridge Rd, [illegible] New Rd, Peckham Rd, Queen's Rd, New Cross, Lewisham [illegible] Rushey Green
This Service is run in conjunction with Messrs Thos Tilling, Ld., Peckham

37 HERNE HILL — HOUNSLOW (Bell Hotel)
Weekdays [illegible] am – [illegible] pm; 1[illegible] pm* – 11.[illegible] pm* | [illegible] am – [illegible] pm; 10 pm† – 11.[illegible] pm† | Every 5 min
Sundays [illegible]; [illegible] pm* – 11.[illegible]; [illegible].17 am‡ – 10.[illegible] am‡ | [illegible]; 10.6 pm† – 11.12 pm† | Every [illegible]
Via Brockwell Park, [illegible] Clapham Park Rd, [illegible]

38 VICTORIA STATION — LEYTON.
Weekdays [illegible] | [illegible] | Every [illegible]
Sundays [illegible] | [illegible] | Sundays every [illegible]
Via Hyde Park Corner, Piccadilly, Shaftesbury Avenue, New Oxford St, [illegible]

39 VICTORIA STATION — SIDCUP.
[illegible]
This Service is run in conjunction with Messrs Thos Tilling Ld, Peckham

40 ELEPHANT & CASTLE — UPTON PARK.
Weekdays [illegible]
Sundays [illegible]
Via [illegible] Fenchurch St, [illegible] Commercial Rd, East India Dock Rd, [illegible]

41 TUFNELL PARK — OLD FORD.
Weekdays [illegible] am* – [illegible] pm; 8.20 [illegible] – 11.1[illegible] | [illegible] am – [illegible] pm | Every 10 [illegible]
Via Brecknock Rd, York Rd, King's Cross, Gray's Inn Rd, Holborn, Bank, Liverpool St, Shoreditch, [illegible] Rd. * Bank only
NOTE This service does not run on Sundays.

42 FINSBURY PK. — TOWER OF LONDON
Weekdays [illegible] am – 10.[illegible] pm; 10.[illegible] pm* – [illegible] pm* | [illegible] am – 10.[illegible] pm; 10.[illegible] pm* – 11.40 pm* | Every [illegible] min
Sundays [illegible].10 am – [illegible] | [illegible] – 10.42 pm
Via [illegible] Upper Clapton Rd, Mare St, Cambridge Heath Rd, [illegible]

43 LONDON BDGE. STN. — MUSWELL HILL.
Weekdays 7.4 am – 11.[illegible] pm; 11.54 pm* – 12.10 am* | [illegible] | Every [illegible]
Sundays 8.00 am – [illegible]; 10.3 pm* – 11.56 pm; 0.20 am† – 11.20 am† | [illegible]; 9 am† – [illegible]
Via London Bridge, [illegible] City Rd, Upper St, Islington, Highbury, [illegible]

44 HIGHGATE — PUTNEY COMMON.
Weekdays 7.45 am – [illegible] | [illegible] | Every [illegible]
Sundays [illegible]
Via [illegible] Camden Town [illegible]

45 CLAPHAM COMMON — SWISS COTTAGE.
[illegible]
Via Clapham Park Rd, [illegible]

46 VICTORIA STATION — KILBURN
[illegible] – 10.8 [illegible]
NOTE This Service does not run on Sundays

47 BROMLEY — SHOREDITCH CHURCH.
[illegible]
Via High St, [illegible] Catford, [illegible] Green, Lewisham, [illegible]
This Service is run in conjunction with Messrs Thos Tilling Ld, Peckham

48 TOTTENHAM — MERTON
[illegible]

49 SHEPHERD'S BUSH — STREATHAM COMMON
[illegible]
Via [illegible] Rd, Kensington, [illegible] High Rd

50 LIVERPOOL ST. — SHEPHERD'S BUSH.
[illegible] | Every [illegible] min
Via Bank, G.P.O., Holborn, Oxford St, Marble Arch, Bayswater Rd, Notting Hill [illegible]
NOTE This Service does not run on Sundays.

51 ▪ SOMERSET H'SE — HAMPTON COURT.
10 am – [illegible] pm | [illegible] | Every [illegible]
Via Charing Cross, Piccadilly, Hyde Park Corner, Fulham Rd, Putney [illegible]

53 ▪ EBURY BRIDGE — NORTH FINCHLEY.
9.4[illegible] am – 8.[illegible] pm; 8.20 pm* – 11.21 pm* | [illegible] | Every [illegible]
The same route as [illegible] Green, Hampstead [illegible]

55 ▪ ELEPHANT & CASTLE — BUCKHURST HILL.
10.4[illegible] am – [illegible] | [illegible]
Via Borough, [illegible] Aldgate, Mile End Rd, Bow, [illegible]
NOTE — This Service is also run on Saturdays.

56 ▪ ELEPHANT & CASTLE — CHINGFORD.
[illegible] | 10.[illegible] am – 10.10 [illegible]
The same route as [illegible] No. 35 to Leyton, thence [illegible]

59 OXFORD CIRCUS — CROYDON.
Weekdays 7.[illegible] am – [illegible] | [illegible] | Every [illegible]

Sundays only **CAMDEN TOWN — CROYDON.**
[illegible]
The same route as No. [illegible] Streatham [illegible]

61 ▪ BRIXTON — WHYTELEAFE.
[illegible]

62 HIGHGATE (Archway Tavern) — WATERLOO STA.
[illegible]
NOTE This Service does not run on Sundays

63 ▪ OXFORD CIRCUS — SIDCUP.
[illegible]
Via Charing Cross, [illegible] Elephant & [illegible]
This Service is run in conjunction with Messrs Thos Tilling Ld, Peckham

64 ▪ OXFORD CIRCUS — BROMLEY.
[illegible]
The same route as [illegible] No. 63 to Lewisham, thence via [illegible]
This Service is run in conjunction with Messrs Thos Tilling Ld, Peckham

65 STOKE NEWINGTON — FULHAM
[illegible]

66 WILLESDEN — TOOTING.
[illegible] am – 1[illegible].30 pm; 10.[illegible] pm* – 11.[illegible] | 7.37 am – 11.45 pm | Every [illegible]
Sundays [illegible]
Via [illegible] High St, Harlesden, Wood Lane, Shepherd's Bush, Hammersmith, Fulham Palace Rd, [illegible] Wandsworth, Garratt Lane

NOTICE. — Every care has been taken in compiling this list, but the Company cannot hold itself responsible for any inaccuracies. The times given refer to the departure of first and last Omnibuses from the termini of the Service under which they are placed respectively.

▪ On Sundays only.

67 LEYTON (Bakers Arms) — POPLAR (Blackwall Tunnel)
Weekdays [illegible] am – 11.6 pm | 8.10 am – 11.56 pm | Every 7-8 min
Sundays 9 am – 11.3 pm | 9.50 am – 11.56 pm
Via High St, High Rd, Angel Lane, Gt. Eastern Rd, Stratford Broadway, [illegible] Plaistow Rd, High St Plaistow, Balaam St, Barking Rd, Iron Bridge, East India Dock Rd.

69 POPLAR — PLUMSTEAD.
Weekdays 7 [illegible] pm | 7.44 am – [illegible] pm | Every 10 min
Sundays [illegible] | 9.44 am – 11.4 pm
[illegible] Woolwich Rd, Albion Rd, George [illegible]

70 KENSAL RISE — SOUTH HACKNEY.
Weekdays [illegible] pm | 6.40 am – [illegible] pm | Every 6 min
Sundays [illegible] – [illegible].20 pm | 9.[illegible] am – 9.15 pm
Via same route as No. 6 to Shoreditch, thence via Hackney Rd, Cambridge Heath, [illegible] Park Rd.

72 LIVERPOOL ST. — WORMWOOD SCRUBS.
Weekdays [illegible] – 10.30 pm | 7.44 am – 11.[illegible] pm | Every 4 min
Sundays [illegible] am – 10.40 pm | 10.2 am – 11.54 pm
Via same route as No. 11 to Hammersmith, thence via Shepherds [illegible]

74 CAMDEN TOWN — KENSINGTON GARDENS.
[illegible] pm | [illegible] am – 10.[illegible] pm | Every [illegible] min
Sundays [illegible] – 11.[illegible] pm | 10 am – 11 [illegible] pm
Via [illegible] Albert Rd, [illegible] St John's Wood Rd, Grove Rd, [illegible] Rd, [illegible] Kensington Terrace, Bishops Rd

75 WOOLWICH (Free Ferry) — CROYDON (Swan & Sugar Loaf)
New Service.
[illegible] Blackheath Village, Lee Rd, Lee Green, [illegible] Rd, [illegible] Catford Hill, Perry Hill, [illegible] Park, Penge, [illegible] Rd, West Croydon Stn
This service is run in conjunction with Messrs Tilling, Ltd

76 STOKE NEWINGTON — VICTORIA STATION.
[illegible] | [illegible] – 11.[illegible] pm | Every [illegible]
Sundays [illegible] | [illegible] am – 11.0 pm | Every [illegible]
[illegible] Westminster [illegible]

77 KING'S CROSS — EAST HILL.
[illegible]

80 EALING BROADWAY STATION — NORTHFIELDS STATION.
[illegible]

MAP & GENERAL GUIDE

JANUARY

1913

WEEKDAY AND SUNDAY SERVICES

LONDON GENERAL OMNIBUS COMPANY LIMITED

· ISSUED MONTHLY ·

81 HOUNSLOW — WINDSOR CASTLE.
Weekdays [illegible] am – [illegible] pm; [illegible].15 pm* – 1[illegible] pm*; [illegible] am* – [illegible] am* | [illegible] | Every [illegible]
Sundays [illegible]
(Alternate [illegible] Hounslow Barracks station [illegible])
Via Bath Rd, [illegible]

82 HESTON HOUNSLOW STATION — STAINES
Weekdays [illegible]
Sundays [illegible] am – [illegible] pm | 1.4[illegible] am – [illegible] pm
Via Bedfont and Staines Road

83 GOLDERS GREEN STATION — EDGWARE ROAD.
Weekdays [illegible] am – 11.58 pm | 6.38 am – 11.31 pm | Every [illegible]
Sundays 9 am – 11.40 am | [illegible] am – 11.[illegible] pm
Via Hendon Rd, Station Rd

84 GOLDERS GREEN STN. — ST. ALBANS.
Weekdays 9 am – 8.30 pm | 10.35 am – 1[illegible] pm | Every [illegible]
Saturdays and Sundays 9 am – 8.45 pm | 10.35 am – 10.20 pm | Every [illegible]
Via North Finchley, Whetstone, Barnet, [illegible] Hadley Wood, [illegible] Mimms, London Colney

85 PUTNEY BRIDGE STN. — ROEHAMPTON.
Weekdays [illegible].30 am – 10.40 pm | [illegible] – 11 pm | Every [illegible]

PUTNEY BRIDGE STA. — KINGSTON HILL.
Sundays only 9 am – 10.12 pm | [illegible] am – 11.[illegible] pm | Every [illegible]
Via High St, Putney, Putney Hill, Roehampton Lane, [illegible] Kingston Hill

86 BARKING STATION — BARKINGSIDE
Weekdays [illegible]
Sunday [illegible]
Via [illegible]

87 COLNEY HATCH LANE — CLAPTON
[illegible]

91 EALING BROADWAY — KEW BRIDGE
[illegible]

93 MILE END STA. — ROMFORD
[illegible]

OMNIBUS SERVICES
In connection with the Underground.

Station	Service	
Barking	86	Barkingside [illegible]
Bow Road District Station	93	Romford [illegible]
Camden Town	[illegible]	[illegible]
Chalk Farm	[illegible]	Swiss Cottage [illegible]
Ealing Broadway	[illegible]	Kew Bridge [illegible]
Ealing Broadway	[illegible]	West Ealing [illegible]
Finsbury Park	85	Clapton [illegible]
Finsbury Park	[illegible]	Clapton [illegible]
Golders Green	[illegible]	[illegible]
Golders Green	[illegible]	St. Albans [illegible]
Hammersmith	[illegible]	Barnes [illegible]
Hammersmith	[illegible]	East Sheen [illegible]
Hammersmith	[illegible]	[illegible] Bridge [illegible]
Hammersmith	[illegible]	Tooting [illegible]
Heston Hounslow	[illegible]	[illegible]
Highgate	[illegible]	[illegible] Hatch Lane [illegible]
Highgate	43	Muswell Hill [illegible]
Hounslow Barracks	[illegible]	Windsor [illegible]
[illegible]	[illegible]	[illegible] Newington
[illegible]	[illegible]	West Eal[illegible]
[illegible]	[illegible]	[illegible]
Putney [illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]

L.G.O.Co. MAP.

ALTERATIONS

No. 2. Finchley Road [illegible] Ebury Bridge
28. Wandsworth Bridge to Chalk Farm [illegible]
31. Chelsea [illegible] Swiss Cottage [illegible]
49. Shepherd's Bush to Streatham Common
87. Colney Hatch Lane to Clapton

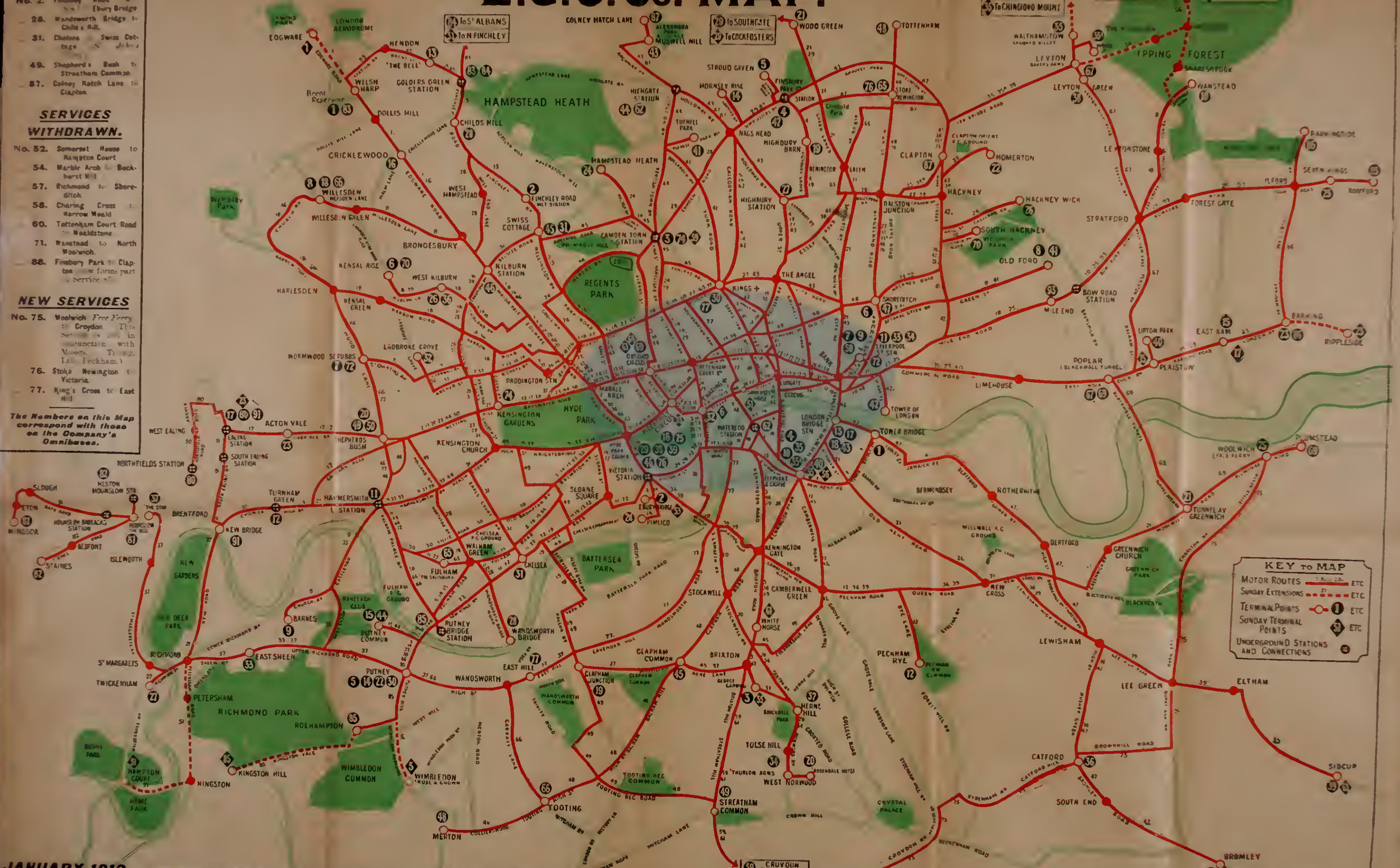
SERVICES WITHDRAWN.

No. 52. Somerset House to Hampton Court
54. Marble Arch to Brockhurst Hill
57. Richmond to Shoreditch
58. Charing Cross to Harrow Weald
60. Tottenham Court Road to Wealdstone
71. Wanstead to North Woolwich.
88. Finsbury Park to Clapton [illegible] forms part [illegible] Service [illegible]

NEW SERVICES

No. 75. Woolwich *Free Ferry* to Croydon [illegible] in [illegible] with [illegible] Peckham.)
76. Stoke Newington to Victoria
77. King's Cross to East Hill

The Numbers on this Map correspond with those on the Company's Omnibuses.



JANUARY 1913. Communications should be addressed to Electric Railway House, Broadway, Westminster.

See reverse side for List of Services.

is a feature of modern life, rendering the provision of transit facilities of supreme importance.

At present, the only complete system attempting to serve London as a whole is its system of motor 'buses, which operate under conditions of unmatched freedom from every point of view. For the moment let us defer the consideration of whether or not such liberty of action is justifiable.* It will be more interesting and instructive to investigate the services which buses render under such exceptionally favourable circumstances. At the outset it should be noted that the effective "door to door" speed rendered possible by motor buses within the central area for average one mile journeys is only about 4 miles per hour, their schedule speed being about 8 miles per hour. In the outskirts although their schedule speed increases to about 10 miles per hour, the effective "door to door" speed is on the average but little better owing to greater time intervals between vehicles.

Fig. 1 and Figs. 2 and 3 respectively give the effective speed for various distances and explain why it is so distressingly low.

Now let us turn to the question of fare rates, returns, operating expenses and profits, to see why 'buses are at present so highly lucrative and to judge of the prospects of their being able to approach the standard of cheap transit established by tramways, which in Glasgow† furnish transport at a uniform fare rate of 0·43 pence per mile, with halfpenny stages throughout.

Until quite recently, the minimum 'bus fare throughout London was one penny. It still remains at this figure in the central area, but in several—though not all—districts outside, the minimum stage has lately been reduced to one halfpenny. The rating of stage journeys is not uniform, varying according to the class of district, nature of the traffic, etc., but chiefly according to the competition of other transit facilities. The only remaining competing facility in all London is the L.C.C. tramway system, and this alone has enforced the granting of halfpenny stages in the bus service.‡ Where bus routes coincide with tram routes the rates of the various stages are practically identical, but otherwise this is not the case. Whereas the rating of a halfpenny stage along a tram route is 0·735d. per mile, a similar stage along a route free from tram competition is rated at 1·2d. per mile.

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* The tables given hereafter clearly indicate that such liberty as the 'bus concern enjoys is certainly not justifiable.

† As a fact, the L.C.C. tramways give results at least as good, if not better than those of Glasgow. If the L.C.C. trams had the same monopoly in London they could do even better than the Glasgow tramways.

‡ This is not the only concession that L.C.C. trams have secured for London, so that Londoners would indeed be thoughtless if they did not support their own tramways.

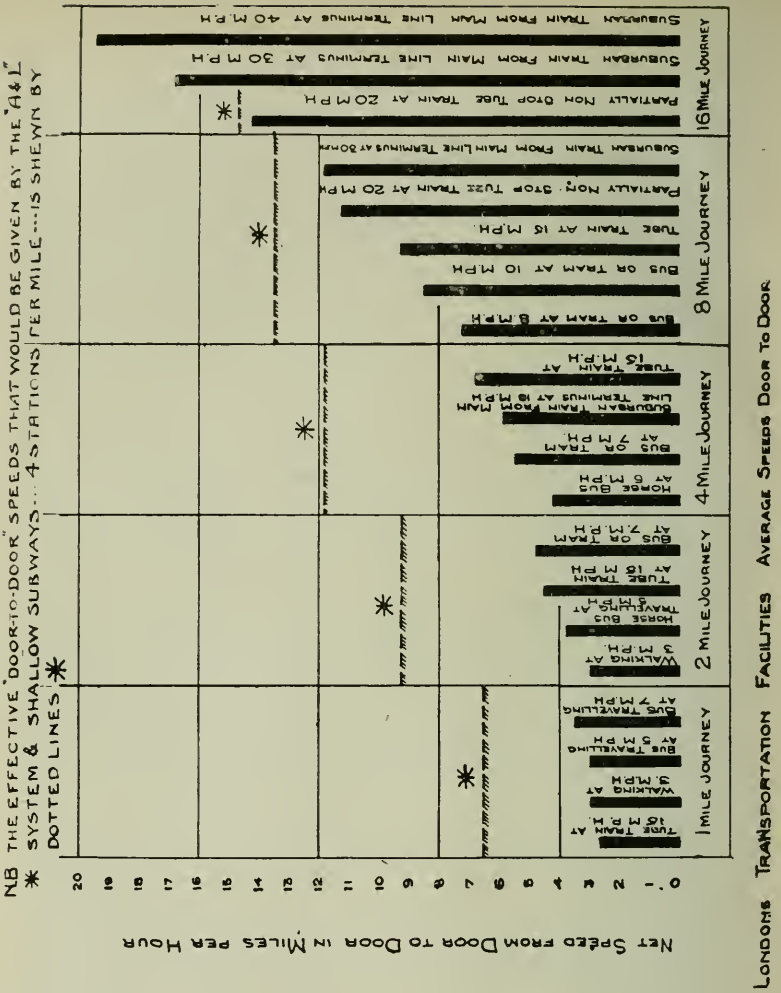

FIG. 1.—EFFECTIVE " DOOR-TO-DOOR " SPEEDS.

[In this diagram it is assumed, for journeys *via* 'buses and trams, a that four minutes are occupied at each end in walking and waiting before boarding and after alighting.

When the journey is *via* tube railways, six minutes are assumed to be occupied in walking to and from the nearest station, and six minutes in getting between street and train, and *vice versa* (owing to lifts, passages, etc.).

When for comparatively long distances the journey is *via* suburban or main line terminals, twelve and a half minutes are allowed at each end on the assumption that traveller has considerably further to walk.

The effective " door-to-door " speed that would be possible with Adkins-Lewis Subways (as shown in Fig. 5), are indicated by the dotted lines marked with an asterisk.]

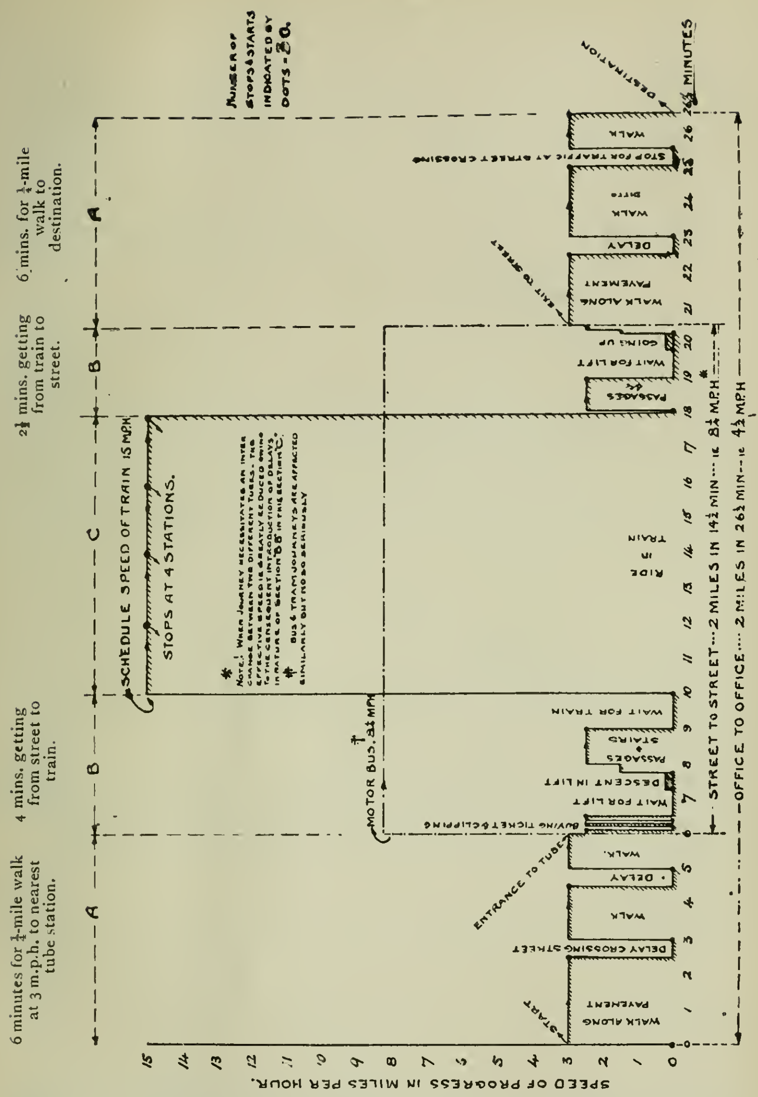

FIG. 2.—AVERAGE TWO-MILE JOURNEY "DOOR-TO-DOOR" SPEED, *via* TUBE RAILWAYS AND MOTOR 'BUSES.

Note, that, in order to give schedule speed of 15 miles per hour on route having two stations per mile, the train has to attain a maximum or "crest" speed of about 25 miles per hour. Similarly, 'buses and trams have to attain high crest speeds to give a schedule speed of 8 miles per hour. The effective speed for one mile journeys on 'buses or trams would be only about 6 miles per hour (see Fig. 3).

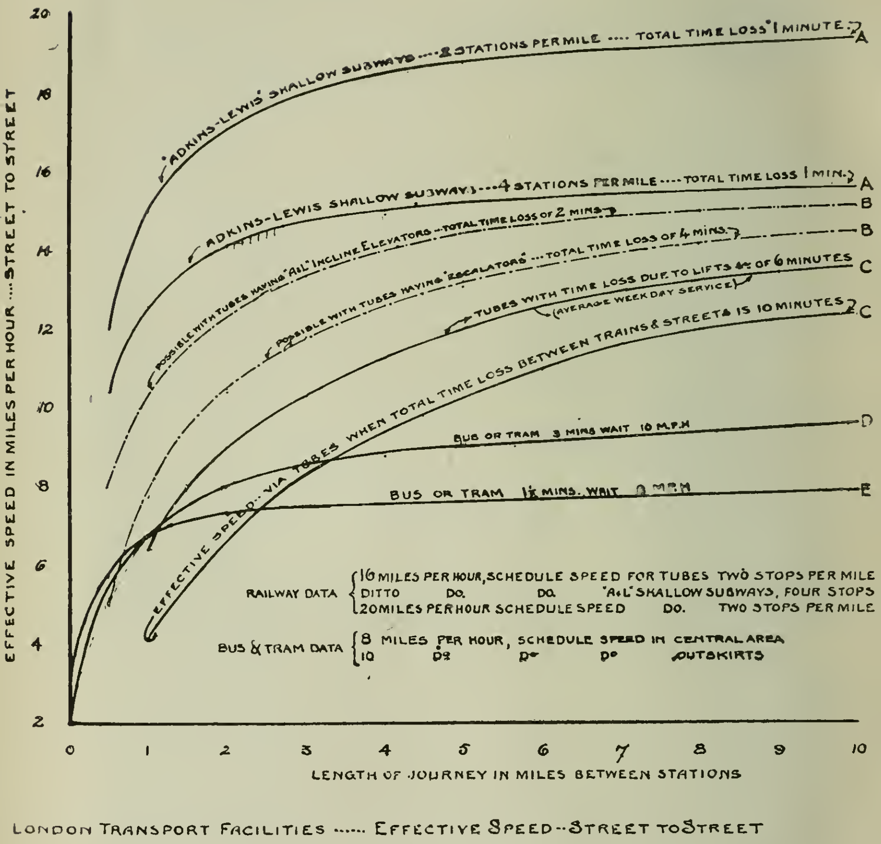

Fig. 3.—Curves.—A. Adkins-Lewis subway. BB. Tubes with continuous elevators. CC. Tubes with present lifts. D. 'Buses and Trams in outskirts. E. 'Buses and Trams in central area.

In the case of one penny stages, the ratings are respectively 0·468d. and 0·625d. In the central area, where 'buses have the monopoly, and where the minimum fare is a penny, the penny stages are rated at from 0·8d. to 1·34d. per mile. The average 'bus rate all over London is certainly not below 0·75d. per mile (three quarters of a penny per mile). This, however, does not mean that Londoners pay on the average for their 'bus rides at the rate of five-eighths of a penny per mile ridden. Far from this being the case, Londoners have to pay so very much more that, notwithstanding the prevailing general—though quite erroneous—impression that London is pre-eminently the city of cheap transit, it is, on the contrary, in fact, the city of most expensive and by no means rapid transit. This fact has never yet been adequately realized, and its consequences have not been in the least appreciated, because Londoners, instead of comparing their transit facilities with those of other capitals, are content to pride themselves on the improved facilities they enjoy in comparison with those they had to put up with ten years ago. The author's indictment applies to all services, but he will not pursue the matter further at the moment.

Let us continue the consideration of the conditions prevailing in the motor 'bus service. Passengers, particularly in in the central area, are in the habit of jumping on buses for very short rides, chiefly owing to the difficulty of walking along the intolerably congested pavements, and to the danger and loss of time involved in crossing the streets. In a large number of cases, the distance ridden does not exceed a quarter of a mile, so that with one penny minimum fares, they pay the 'bus company at the extortionate rate of 4d. per mile. In a very large number of cases, the distance ridden does not exceed half a mile—when similarly the rate per ridden mile is 2d. Those who ride one mile pay at the rate of 1d. per mile, whilst for those who ride 1⅓ miles, the actual rate paid is at least 1⅛d., and often 1½d. per ridden mile.

It is undoubtedly true, that the vast majority of journeys taken in London (and indeed in all great cities) over all facilities averages less than two miles. The L.C.C. Tramway returns clearly indicate that fully 75% of the journeys are less than two miles. So far as the author is aware, no attempt has yet been made to determine the actual average length of journey and rate paid per ridden mile. Yet these are extremely interesting and important matters. Although the 'bus authorities most jealously guard and withhold, even from the Government, their records and data, it is possible to make, from data which is common knowledge, an investigation giving with sufficient accuracy both the average length of journey actually ridden and the actual rate per mile paid. These two items being mutually dependent, the results check each other within self-evident limits, so that they are bound to be at least very close to accuracy. At any rate, they are sufficiently so to reveal that the 'bus people have good reason for their secrecy and disinclination to let Londoners know how extortionately they are being charged for the doubtful blessings of 'bus services.

Let us, therefore, proceed with the investigation. 'Bus owners have admitted that the average receipts per 'bus-mile amount to 10½d. Owing to the recent large increase in the number of 'buses in service, possibly the present receipts per 'bus-mile are somewhat less, though in all probability the receipts do at present, or certainly will in the near future, exceed this figure. From recent returns* of L.G.O.C. gross receipts aggregating £59,000 per week on the present stage ratings, it is clear that with 2,000 'buses running an average of 100 miles per day the average receipts per 'bus mile would be $\left(\frac{59,000\times240}{2,000\times700}=\right)$ 10⅛d.

The author is aware that the L.G.O.C. held licenses, early in November last, for some 2,240 'buses, which by the end of 1912 increased to 2,600, and that it may be said that the Company runs a greater daily number of 'bus-miles, so that the returns per 'bus mile are considerably less. It will be seen, however, that this is most unlikely, and that if such be really the case, it is done for the express purpose of concealing exorbitant fares and resulting profits. If there is any quibbling, let the Traffic Trust publish complete returns, as the Government should insist upon its doing. The average fare is bound considerably to exceed one penny. It cannot under prevailing conditions average less than 1⅛d., for all London. Then $\left(\frac{10.125}{1.125}=\right)$ reveals 9 fares per 'bus mile :—Surely 'bus exponents will admit such a low average even for the whole year and all London.

Now bearing in mind that even underground railways, having a much more regular traffic than any surface facility could possibly have, cannot be operated with such a nicety that less than three seat-miles be run per passenger-mile (*i.e.* per mile actually ridden by the passenger), it is highly improbable that 'buses can be operated so that on the yearly average the ratio of seat-miles run to passenger-miles ridden be less than 3.33 to 1. In other words, in view of variations of street traffic, the uselessness of outside seats in wet weather, and such like

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* The L.G.O.C. returns are rapidly increasing, and indicate that custom is being extensively taken from L.C.C. trams. See returns for week ending January 4th, 1913. In addition to these receipts, those of the 94 'buses operated by the N.S.C. Co. and the 100 'buses operated by the T.S. Co. should be taken into account.

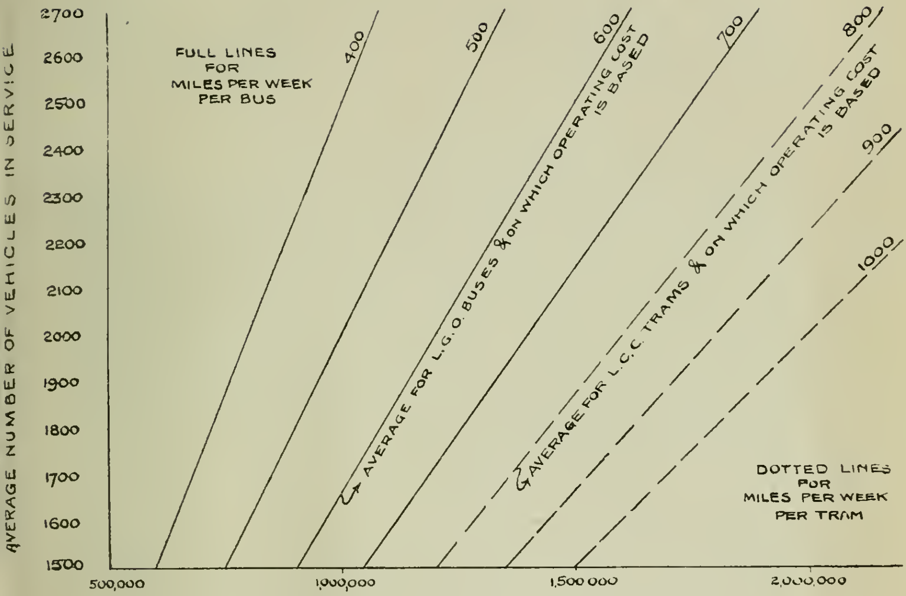

FIG. 4.—CAR MILEAGE PER WEEK—AGGREGATE.

Diagram to find number of cars in service for given mileage.

Note that a 'bus runs for 30,000 to 35,000 miles per annum, whilst a tram runs 42,000 to 46,000 miles per annum.

considerations, it is hardly possible to furnish and so to regulate an adequate supply of seating accommodation that, on the overall average, the 'buses be more than one-third fully loaded. This being so (and such a low ratio is a handsome attainment) a 34-seat-'bus-mile would average $\left(\frac{34}{3\cdot 33}=\right)$ 10·32 passenger miles. Since there are nine fares picked up per 'bus-mile, we find that the average length of journey or distance actually ridden is $\left(\frac{10\cdot 32}{9}=\right)$ 1·147 miles, and that the average rate per mile actually ridden is $\left(\frac{10\cdot 125}{10\cdot 32}=\right)$ 0·98d.

Proceeding a step further in the investigation, we may note that the vast majority* of 'bus routes pass through the central area, indicated in blue on the L.G.O.C. route map attached, also that a fair average length of route is 10 miles, of which 3 miles can be taken as through some portion of the central area, which may be called the " 'Bus Paradise," whilst the remaining 7 miles is through less lucrative districts—urban or suburban—say 3½ miles on both sides of " Paradise." It is reasonable to assume that the average number of fares picked up per mile in the central area is quite double the number picked up per mile in the districts outside. Thus we get :

TABLE I.

10 *Mile 'Bus Route across London.*

Outskirts :	7 miles at 7 fares per mile	49	fares
Central area :	3 miles at 13⅔ fares per mile	41	,,
	Total fares for 10 *miles at an average of* 9 *per mile* ...	90	,,

Since the length of stages is longer in the suburbs than their equivalent in the central area, and further since the average length of journey is also longer in the suburbs than in the central area, we find that to give an overall average fare of 1·125d. on the above basis of route proportions, the average fare in the suburbs must be 1·0625d. and 1·2d. in " Paradise." Thus we have :—

TABLE II.

Bus Receipts along 10 *mile Route.*

	miles.	fares.		d.		d.		d.	
Outskirts ...	7 ...	49	@	1·0625	=	52·062	or	7·43	per 'bus mile
Central area ...	3 ...	41	@	1·2	=	49·2	,,	16·24	,, ,,
Total & Average	10 ...	90	@	1·125	=	101·26	,,	10·125	,, ,,

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* Of 93 'bus routes, including over a dozen outer suburban and Sunday services, run on a time service of from 10 min. to 30 min., all but 15 pass through the central area, each 'bus crossing it. on the average, 10 times per day.

Since we have already found the average rate per mile ridden to be 0·98d., and the average distance travelled to be 1·147 miles, we get the following :—

TABLE III.

10 *Mile Route—Rates per ridden mile and passenger-miles per bus-mile.*

Outskirts : 7 b.m. Receipts 52·062d. @ 0·875d. per p.m. =59·5 p.m. or 8·5 p.m. per b.m.

Central area : 3 b.m. Receipts 49·2d. @ 1·125d. per p.m. =43·73 p.m. or 14·6 p.m. per b.m.

Total & Average : 10 b.m. Receipts 101·26d. @ 0·98d. per p.m. =103·23 p.m. or 10·32 p.m. per b.m.

TABLE IV. BUSES.

Ratio :—Seat-miles to passenger-miles.

Outskirts ...	34 : 8·5	:: 4 to 1 or	8·5	seats occupied	&	25·5	empty
Central area	34 : 14·6	:: 2·33 to 1 or	14·6	,,	,,	19·4	,,
Overall ...	34 : 10·32	:: 3·3 to 1 or	10·32	,,	,,	23·68	,,

In columns 9 and 10 of Table V., are respectively given the distribution of 'bus mileage when 2,000 'buses are in service aggregating 700 miles per week each, and the corresponding gross receipts per week. In columns 11 and 12 of the same table are respectively given gross costs per 'bus mile and the corresponding net profit per bus mile. These are based on the operating expenses being 6·8d.* per bus-mile, since bus people now generally boast that the figure is actually below 7d. per bus mile, including all charges. The same average cost has been taken for both central area and outskirts, because although the road surface may be better in the central area, the loading is heavier, and the number of stops and starts greater. On the other hand, the speed in the outskirts is higher. Column 13, gives the aggregate weekly net profits for the different sections of route. Since 85% of the profit is made in the central area, it is not to be wondered at that nearly all the 'bus routes are through some or other of the important thoroughfares in the central area. It is not because 'buses act so beneficially as long distance feeders to and from the central area, for it is clear that the average length of journey is very short, much shorter than has hitherto been generally supposed.

The percentage of tickets issued for comparatively long journeys is so small as to be practically insignificant, and certainly does not warrant the claims made by 'bus enthusiasts in this direction. It is almost certain that tickets issued for all journeys above 2d. stages (*i.e.* beyond say 3¼ miles), is well under 10% of the total 'bus tickets issued, a radius which does not take one far out of the central area itself. For the same

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*See Appendix (page 48) for detailed estimate of gross operating cost.

TABLE V.

Summary for 'bus service.

District.	1 Dis-tance.	2 No. of fares per b.m.	3 Average fare picked up.	4 Receipts per b.m.	5 Rates per ridden mile.	6 Average length of journey.	7 Pass. miles per b.m.	8 Ratio s.m. to p.m.	9 Weekly bus mileage in millions.	10 Gross Receipts per week.	11 Gross cost per b.m.	12 Profit per bus-mile.	13 Aggre-gate weekly net profits.
Suburbs ...	7	7	1·0625	7·43	0·875	1·21	8·5	4·00	0·98	£ 30,580	6·8	0·63	£ 2,876
Central area ...	3	13·66	1·2	16·24	1·125	1·065	14·6	2·33	0·42	28,420	6·8	9·44	16,520
Overall ...	10	9 *	1·125	10·125	0·98	1·145	10·32	3·33	1·4 *	59,000	6·8	3·325	19,396

* * (9 × 1,400,000 × 52) =655,200,000 passengers per annum.

reason, it is clear that the traffic inter-connecting between urban districts across the central area is not, as far as surface facilities are concerned, so heavy as seems to be imagined by many people.

The author realizes that, at first sight, the receipts of 10⅛d. per 'bus mile and the other data taken to construct Table V. may appear to present the conditions of 'bus operation too favourably. It therefore seems desirable at this point to explain that if the bus-mile receipts are less, then 'buses are being operated at a loss in the suburbs, since Table V. shows a profit of only 0·63d. per 'bus mile, or £82 10s. 0d. per annum. It is known, however, that 'buses operating entirely in the suburbs can be very profitably worked at the exorbitant stage rates in vogue—otherwise the Metropolitan Co. would not have adopted them recently. Still, it may be that the L.G.O.C. in order to develop suburban traffic and possibly to conceal the situation, are running their 'buses in the outskirts at a loss. They obviously could afford to do so, but such action is evidently unnecessary, as Table V. indicates that the buses in the outskirts would be only quarter loaded even for average receipts of 10⅛d. per 'bus mile. Surely the Traffic Trust would not needlessly increase wear and tear of roadways, which is already high enough ?

In Table VI. other tables indexed A, B, C, D, E, and F, are given for different amounts of receipts per 'bus-mile, different average fares, and slightly different conditions of operation. Contrary to Table V. being too favourable, everything points to the receipts being nearer 12d. or 12½d. per 'bus-mile, with 1½d. or 1¼d. as the average fare, giving the astounding results set forth in Table VI.(C) or (F). In any case, it is clear that Londoners are being exorbitantly charged for the services rendered by motor 'buses, and the time is ripe for them to take such action as will ensure reform.

Let us confine attention for a few moments to what is happening in the " Bus Paradise " the lucrative central area, of which 'buses have the monopoly, and wherein they are allowed to rook an innocent and absolutely unguarded public. Here, even according to Table V., they have to run only 2.1 seat-miles, costing 0·42d., to pick up a penny and make a profit of 0·58d., in other words, 58% of every penny collected is clear profit. It is highly probable that the rate per ridden mile is actually higher than 0·98d.* shown by Table V. Still, that figure is sufficiently high to warrant Londoners pausing to think " furiously." Is that reasonably cheap transit ? Obviously the Traffic

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* Even this figure is at least 50% higher than the rate per ridden mile charged by tube railways, which provide transit at fully double the schedule speed, a fact which indicates that the capital cost of a system is no criterion of its advantages.

TABLE VI. 'BUS SERVICE. ESTIMATED RESULTS FOR 1913.

	1	2	3	4	5	6	7	8	9	10	11	12	13	
Districts.	Distances. Miles.	No. of fares per b.m.	Average fare Pence.	Receipts per b.m. Pence.	Rates per ridden mile. Pence.	Average length of ride. Miles.	Pass. miles per b.m.	Ratio of s.m. to p.m.	Weekly bus mileage. Millions.	Gross receipts per week. £	Gross cost per b.m. Pence.	Profit per bus-mile. Pence.	Aggregate weekly net profits.	Index letter.
Outskirts ...	7	7	1·187	8·31	0·875	1·36	9·5	3·59			6·8	2·51		
Central area	3	13·66	1·062	14·38	1·125	0·93	12·78	2·66			6·8	7·58		A
Overall ...	10	9	1·125	10·125	0·96	1·163	10·47	3·24	1·4	59,000	6·8	3·325	£19,396	
Outskirts ...	7	7	1·125	7·87	0·75	1·5	10·5	3·24			6·8	1·07		
Central area	3	17	1·125	19·125	1·25	0·9	15·3	2·3			6·8	12·325		B
Overall ...	10	10	1·125	11·25	0·94	1·19	11·9	2·86	1·259	59,000	6·8	4·45	£23,344	
Outskirts ...	7	6	1·625	9·7	1·0	1·62	9·7	3·5			6·8	2·9		
Central area	3	13	1·375	17·8	1·25	1·1	14·3	2·38			6·8	11·0		C *
Overall ...	10	8	1·5	12·0	1·09	1·4	11·1	3·06	1·18	59,000	6·8	5·3	£26,000	
Outskirts ...	7·5	6	1·5	9	0·875	1·71	10·28	3·31			6·8	2·2		
Central area	2·5	14	1·5	21	1·125	1·33	18·64	1·8			6·8	14·2		D *
Overall ...	10	8	1·5	12	0·97	1·546	12·37	2·75	1·18	59,000	6·8	5·2	£25,500	
Outskirts ...	7·5	7	1·25	8·89	0·875	1·45	10·15	3·35			6·8	2·2		
Central area	2·5	19	1·25	23·4	1·125	1·09	20·75	1·64			6·8	16·6		E *
Overall ...	10	10	1·25	12·5	0·965	1·28	12·83	2·65	1·1328	59,000	6·8	5·7	£27,000	
Outskirts ...	7	7	1·375	9·63	1·0	1·38	9·63	3·54			6·8	2·83		
Central area	3	17	1·125	19·125	1·25	0·9	15·3	2·25			6·8	12·325		F *
Overall ...	10	10	1·25	12·5	1·1	1·132	11·32	3·1	1·1328	59,000	6·8	5·7	£27,000	

Weekly Returns £59,000 {
A Receipts per 'bus-mile = $10\frac{1}{8}$d. ... Average fare $1\frac{1}{8}$d.
B ,, ,, = $11\frac{1}{4}$d. ... ,, ,, $1\frac{1}{8}$d.
C ,, ,, = 12d. ... ,, ,, $1\frac{1}{2}$d.
D Receipts per 'bus-mile = 12d. ... Average fare $1\frac{1}{2}$d.
E ,, ,, = $12\frac{1}{2}$d.... ,, ,, $1\frac{1}{4}$d.
F ,, ,, = $12\frac{1}{2}$d.... ,, ,, $1\frac{1}{4}$d.

** Tables "C" and "D" give 490,880,000 passengers per annum. Tables "E" and "F" give 589,056,000 passengers per annum.

Trust could afford to reduce the rates, though this would not meet the real need of Londoners.

What is wanted is the introduction of halfpenny stages, rated at ½d. per mile, not extortionately rated at 1¼d. per mile, as in the case of the halfpenny stages on the Marble Arch to Cricklewood service. Whilst 'buses could not at present, and apparently not in the future, be run profitably with ½d. stages based on the Glasgow Tram flat rate of 0·43d. per mile, they could be worked at reasonably sufficient profit with halfpenny stages rated at ¾d. per mile. Such a concession would be a great boon, and it is overdue to London. Its introduction would undoubtedly, as in Glasgow, enormously increase the number of journeys taken, which in itself is strong evidence of the public's aching need of the beneficial results of cheaper transit. This would be one of the reforms that possibly a "London Traffic Association" might usefully work to attain. Let us see what results would accrue to the 'bus concern if worked on the basis of halfpenny stages rated at ¾d. per mile. No doubt more buses would have to be crowded into "Paradise," though it is inconceivable that there is room for many more in that congested district. In any case, however, bearing in mind the uselessness of the outside seats of 'buses in wet weather, and other important considerations, 'buses could not be operated with such regulation all over London that less than three seat-miles be run per passenger mile ridden. Thus assuming that the passengers ride the full stage distances, the receipts per 'bus-mile would become $\left(\frac{34 \times 3}{4 \times 3} = \right)$ 8½d. As regards the total expenses per 'bus mile it is reasonable to assume that any increase of the present cost, due to augmentation of the petrol tax (which in view of the present huge profits is not an unreasonable nor unwise demand provided that steps be taken to prevent an increase of fare ratings) or to other possible contingencies, would be at least offset by improvements which motor 'bus enthusiasts so volubly predict. Thus we may as before take the expenses per 'bus-mile to be 6·8d. This yields a net profit of $(8 \cdot 5 - 6 \cdot 8 =)$ 1·7d. per 'bus-mile, or on the basis of 100 miles per day and only 300 days per annum a profit of $\left(\frac{1 \cdot 7 \times 300 \times 100}{240} = \right)$ £212 per 'bus per annum. Surely the Traffic Trust should be content with this handsome return, seeing that their 'buses actually cost only about £450.

The author will conclude his investigation of the 'bus question by a brief reference to the petrol tax. This, at 1½d. per gallon amounts to 0·2d. per 'bus-mile, or for 2,000 'buses running 1,400,000 'bus-miles per week, £1,166. According to the distribution of bus-mileage in Table V., if instead of petrol tax receipts being handed over to the Road Board, they be given to the Boroughs on a mileage basis, £350 per week would be due to the central area, and £816 per week to the suburbs. Is £60,632 per annum enough to repair the damage to roads all over London by the motor 'bus service ?

Regarding the comparison of this tax on a seat-mile basis, made by the London Traffic Branch of The Board of Trade and others who have tried to establish as a fact that 'buses pay more in this way than trams do in the various ways in which they are taxed,* we may note here that the seat mileage is no gauge of the amount that should be contributed. Surely if any tax is at all justifiable,† it should be proportionate to road damage done, based on ton mileage according to speed and class of vehicle ? Without pursuing the matter further in this paper, it may be noted that, since a 'bus occupies 166 sq. ft. of road space $\left(\frac{2{,}000 \times 166}{9}\right)$ say 36,000 sq. yds. of London's roads are continually in possession of the Traffic Trust. Through the petrol tax they pay at the rate of $\left(\frac{\pounds 1{,}166}{36{,}000} = \right)$ 7¾d. per sq. yd. per week for the accommodation. This is not much by way of rental, and doubtless the 'bus company covers a good proportion of the contribution by its charges for advertisements. In this connection it would be interesting to find out what revenue advertisements bring to the L.G.O.C. coffers.

Let us now turn to the L.C.C. Tramways. Full and complete statistics and returns are issued to the public, in which of course are included its rivals. The system is practically ex-

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* The annual contributions to public funds by trams and 'buses are as follows :—

	Per Tram £ s. d.	Per 'Bus £ s. d.
Licence Duties	2 15 0	5 18 0
Rates on Track	84 0 0	nil
Road maintenance	96 0 0	nil
Contribution to street improvements ...	19 0 0	nil
Petrol tax at 0·2d.‡ per 'bus-mile and 30,000 miles per annum	nil	25 0 0
Total ... ...£	201 15 0	£30 18 0

† The author does not believe that any tax on transport facilities is justifiable provided the facilities are properly controlled and managed.

‡ The figure 0·3d. per 'bus mile given by B.O.T.-L.T.B. Report, 1911, is more than 50% too high. See Appendix for details of cost per 'bus mile, Petrol Tax is 0·188d. per 'bus mile or £31 16s. per annum on basis of 35,000 mileage per 'bus.

cluded from the lucrative central area. True, some of its lines terminate within the fringe, but any fair-minded student of traffic problems will at once acknowledge that the tramways at present cannot be considered as operative in the central area. The single inter-connection is an underground one *via* an undeveloped new thoroughfare, whilst the dead-ended tram lines projecting into the small sections of the central area comprised between the river from St. Thomas' to Tower Bridge, and the Elephant, together with those in the Finsbury and Clerkenwell districts, cannot be compared with such thoroughfares as Oxford Street or the Strand. Moreover, these insignificant encroachments upon the 'bus " Paradise " are eclipsed by the monopolies possessed in several excellent districts outside the central area. Thus we may reasonably conclude that L.C.C. tramway returns almost wholly result from traffic secured entirely outside the central area shown on the plan.

Returns to March, 1912, indicate an average fare of 1·04d. Receipts per car mile 10·98d. ; average mileage per car per day 113 miles ; average number of cars in service 1,179, out of 1,584 in stock. The average number of passengers per car mile is therefore $\left(\frac{10\cdot98}{1\cdot04}=\right)$ 10·58. The number of seats per car may be taken to average 72.

Regarding fare ratings—halfpenny stages are universal and practically uniform at 0·875d.* per mile. Penny stages are rated at 0·47d. per mile, three-halfpenny stages at 0·51d. per mile, two-penny stages at 0·3875d. per mile, and three-penny stages at 0·292d. Workmen's fares are rated at 0·194d. per mile. The vast majority of journey tickets issued are those for penny stages and under. Tickets issued for 1½d. stages and over (*i.e.* 3 mile journeys and over) are only about 26% of the total issued. Since for every half-penny stage ticket issued, there are two-and-three-quarter tickets issued for stages of longer journeys, it will be on the high side to assume that the average mileage rate for tickets issued is $\left(\frac{(2\cdot75\times0\cdot47)+0\cdot875^{*}}{3\cdot75}=\right)$ 0·578d.† As regards the average percentage of the stage distances actually ridden by passengers, this must, with all-round halfpenny stages, be a high one, and remembering that in the case of L.C.C. tram journeys, such as on return trips and workmen's tickets, the stage mileage rate is as low as 0·194d. per mile, it will again be on the high side to take 0·625d. as the average rate paid per mile actually ridden. It will, with the foregoing data, now be interesting to construct Table VII. on the lines of Table V. already given for the 'bus service :—

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* This figure should be 0·73d., since a halfpenny stage averages 1,200 yds. on the L.C.C. tram system.

† This figure should consequently be 0·54d.

TABLE VII. TRAM SERVICE.

L.C.C. Tramway Returns for year ending March, 1912. 516,092,489 *passengers carried.*

	1	2	3	4	5	6	7	8	9	10	11	12	13
District.	Distance. Miles.	No. of fares per Car-mile.	Average fare. d.	Receipts per C.M. d.	Rates per ridden mile. d.	Average length journey ridden.	Pass. miles per C.M.	Ratio S.M. to P.M.	Weekly car mileage.	Receipts per week.	Gross cost per C.M. d.	Profit per C.M. d.	Aggregate weekly nett profits.
Outskirts of Central area	7	10·58	1·04	10·98	0·625	1·66	17·57	4·1	938,000	£ 42,931	7·52	3·46	£ 13,530

TABLE VIII.

L.C.C. Tramways: assuming they served central area without 'bus competition. 1,100,000,000 *passengers carried.*

	1	2	3	4	5	6	7	8	9	10	11	12	13
Districts.	Distance. Miles.	No. of fares per Car-mile.	Average fare. d.	Receipts per C.M. d.	Rate per ridden mile. d.	Average length of journey ridden.	Pass. miles per C.M.	Ratio S.M. to P.M.	Weekly car mileage.	Receipts per week.	Gross cost per C.M.	Profit per C.M.	Weekly nett profits.
All over London	10	18·5	0·731	13·53	0·625	1·25	21·65	3·33	1,142,900	£64,431	7·0	6·53	£31,096

The gross cost per car mile of 7·52d. given in col. 11, is arrived at as follows. The gross revenue from traffic is £2,231,902. Deduct from this £334,176 interest on capital, plus £369,355 redemption of debt, totalling £703,531. The balance of £1,528,371 covers all working expenses, income and other heavy taxes and rates* amounting to £120,397, road repairs £120,000, and contributions to Renewals and General Reserve Funds to £222,703. This balance divided by the aggregate car miles run gives—
$\left(\frac{1{,}528{,}371 \times 240}{48{,}777{,}026} = \right)$ 7·52d. per car mile as the gross operating cost, comparable to the figures given for the 'bus service in Table V. The resulting profits shown on column 12, are sufficient to cover £334,173 interest on capital expenditure (not only for the tramway system itself but also on £534,792 worth of street improvements), and debt redemption (£369,356), at a satisfactory rate.

The comparison of Table VII. with Tables V. and VI. is instructive, since it indicates that the trams serve the public at fully 36·4% less cost, providing much greater seating capacity, and equivalent speeds ; also that the public appreciates these advantages, since the average distance ridden on trams is fully 45% greater than on 'buses.

Let us now see what results would accrue if motor 'buses be prohibited from routes already served by trams, and further that if the tramways be extended in the suburbs and into the central area, thus further eliminating 'buses, which might be better and more safely utilized along routes on which the traffic is insufficient to warrant trams. This would be in accordance with Mr. Pott's views. The extension would comprise the completion of the scheme on which the L.C.C. undertaking was designed. For the moment, questions of capital cost, practicability and advisability need not be considered. It seems quite safe to assume that, apart altogether from increased traffic due to the lower fare ratings and to the all-round introduction of half-penny stages, the increment would be two-thirds of what the 'bus traffic probably will be this year, according to Table V., viz. :—
$\left(\frac{59{,}000 \times 52 \times 240 \times 9}{10 \cdot 125} = \right)$ 654,487,000† passengers, $\frac{2}{3}$ of which would give the trams 436,325,000 extra " fares." Allowing for normal growth of traffic, and a 25% increase due to the introduction of halfpenny stages in the central area, the total " fares " on the completed L.C.C. tramway system might easily reach 1,100,000,000 by the time the change was effected or say within

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* See footnote, page 40. † See footnote, Table VI. " C " and " F."

the next two years. If a uniform rate of a halfpenny per mile, with halfpenny stages throughout be then established, the results would be at least as good as those set forth in Table VIII.

The comparison of Table VIII. with Table VII. and Tables V. and VI., is instructive, even though it may be somewhat speculative.

As to the practicability of tramway extension to such an extent, it is evident that the returns would warrant an expenditure amply sufficient to carry it out. As to the advisability of the proposition, it may become an absolute necessity if 'buses continue to prove so dangerous, and unfairly to rob the tramways of their traffic. From the view-point of street congestion, the change would bring about great relief, since the necessary car mileage could be provided in both central area and outskirts with only about 25% more cars (1,453) than are at present employed in the outskirts. It has been indicated that 2,000 'buses now occupy fully 36,000 sq. yds. of space in London's thoroughfares, in handling about 655,000,000 passenger trips per annum. The 1,179 L.C.C. tramcars in service, last year handling 516,000,000 passenger trips per annum in the outskirts, occupied, at 240 sq. ft. per 72 seat car, equivalent to $\left(\frac{240 \times 1{,}179}{9} = \right)$ 31,440 sq. yds. But under the extensions considered above, giving results set forth in Table VIII., the combined aggregate of 1,318,000,000 passenger trips per annum, could be handled by 1,453 trams occupying 37,850 sq. yards, assisted (in the outskirts only) by say 700 'buses occupying 13,000 sq. yards, making a total of about 50,000 sq. yards, distributed fairly well all over London.

In point of relative cost, it is obvious that the electric tram, even when laid down in the costliest manner, can furnish passenger transport at fare rates which 'buses cannot approach even under more favourable conditions. The importance of this advantage is amply sufficient to outweigh all other considerations put together.

Whilst the foregoing may help to set up a fair consideration of the 'Bus *v.* Tram question, it by no means comprises a comparison between the relative merits of the two systems. In the author's opinion, the only correct way to make a true comparison is to construct a table covering all points, and to allot marks for each according to their respective merits. Opinions no doubt differ considerably as to the importance and significance of various points, but it would be well to determine the consensus of opinion on the more important ones. With this object in view, the author has prepared a comparative Table (Table IX.), in which he has endeavoured to be as fair as possible in alloting the marks. It is hoped that those who are better

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IZE.

1	2		15	16	17	18
System.	ber of Labour conditions.	Freedom from		r mile.	de penny.	de ny n fares.
Petrol 'Bus Data	fair	f	.. ..	.. ..	.. ..	0·2d. 0·3d. (TableV.) £100 50%
Marks ...	5					
Electric Tram Data	good	g	.. ..	.. ..	.. ..	0·1d. 0·153d. £19 6·2%
Marks ...	7					
Adkins-Lewis Data	good		.. on full size scale in public service.	..	..	0·03d.
Marks ...	10					

TABLE IX.

RELATIVE MERITS OF 'BUSES AND TRAMS.

THE MARKS ALLOTTED ARE QUITE ARBITRARY. IT IS HOPED THAT EXPONENTS WILL FREELY CRITICIZE.

	PASSENGERS' ASPECT.																
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
System.	Character of Service.	Number of Stations per mile	Schedule Speed	Street to Street Speed Av. eff. 1 mile.	Max capacity in seats per hr. from Terminal.	Overload capacity or Standing Room.	Access and Egress and Accessibility from Pavement	Protection from Weather and Ventilation.	Seating space per seat.	Vibration and Swaying.	Nature of Acceleration and deceleration.	Noise.	Lighting.	Safety.	Cost per Ridden mile.	Stage ride for one penny.	Max. ride for one penny workmen fares
Petrol 'Bus Data	Inter-mittent	8	8 Cnt. area 10 Suburbs	6¼	2000	nil	fair good	Top seats not pro-tected.	4 sq. ft	bad	bad	bad	fair	moderate	1d.	1·6	nil.
Marks	–	40	20	30	20	0	25	10	5	5	5	5	7	8	30	16	0
Electric Tram Data	Inter-mittent.	*6	7½ Cnt. area 10 Suburbs	6	4500	10%	good fair	Top seats well pro-tected.	4½ sq. ft.	fair	fair	fair	good	good	0·62d	2·1	8
Marks	—	30	18	25	45	5	15	15	5	7	7	7	10	10	48	21	50
Adkins-Lewis Data	Con-tinuous.	4	16	12½	12500	20%	very good	perfect	6	good	perfect	good	very good	perfect	0·25	Any distance within central area for ½d.	
Marks	—	20	40	60	100	10	30	25	10	10	20	15	15	25	100	100	

* Trams can also make 8 stops per mile

See Fig 3.

	PEDESTRIANS' ASPECT						MUNICIPAL AND COMMUNAL ASPECT										
	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35
System.	Smell and Heat ejected.	Street Noises.	Safety.	Street Congestion.	Mud splashing	Unsightliness	Road damage.	Rates, Taxes and other Public Burdens.	Road space per seat.	Flexibility	Property damage (vibration).	Traffic congestion.	Police control of Streets.	Motoring trades.	Tramway and electrical trades.	Tendency towards cheap power.	Prospect of improvements.
Petrol 'Bus Data	bad	bad	very bad	bad	*bad	–	bad	£1·26 per seat *	5 sq ft	—	bad	bad	heavy	—	—	*	—
Marks	0	5	2	5	0	8	5	10	5	20	5	3	2	5	0	0	5
Electric Tram Data	nil.	fair	fair	fair	good	—	good	£3 per seat	3 sq ft.	—	bad	fair	moder-ate		—	†	—
Marks	10	7	10	10	5	10	25	25	8	5	5	5	5	0	10	10	3
Adkins-Lewis Data	nil	nil	perfect	nil	nil	nil	nil	heavy	nil	–	nil	nil	nil	—	–	—	—
Marks	10	25	20	100	10	20	100	50	50	—	50	50	10	—	—	—	—

* In Paris a Pedestrian recently won a claim for damages to clothes mud-splashed by Motor Bus

* Petrol Tax yields about £38 per 'Bus to Road Board, but London at present gets nil.

* The more Petrol used the more expensive it becomes, this affects all motorists detrimentally

† The more Electricity used the cheaper it becomes and this affects all trades beneficially.

	INDUSTRIAL ASPECT.				GENERAL CONCLUSIONS.					REMARKS.
	36	37	38	39	SUMMARY					
System.	Labour conditions.	Freedom from Strikes, and prospects	Fuel and other material consumed	Cheap and Rapid Transit.	Passengers.	Pedestrians.	Municipal and Communal	Industrial	Grand Totals.	
Petrol 'Bus Data	fair	fair	foreign	fair						Gross operating cost per seat-mile .. .. 0·2d. Gross receipts per seat-mile .. .. 0·3d. (Table V.) Receipts per £100 capital .. .. £100 Dividends possible 50%
Marks	5	5	5	5	226	20	60	20	326	
Electric Tram Data	good	good	domestic	fair						Gross operating cost per seat-mile . . 0·1d. Gross receipts per seat-mile 0·153d. Receipts per £100 capital .. . . .. £19 Dividends possible .. .. . 6·2%
Marks	7	7	10	10	318	52	101	34	505	
Adkins-Lewis Data	good	good	domestic	very good						Operating cost per seat-mile . .. . 0·03d. This system has not yet been demonstrated on full size scale in public service
Marks ..	10	10	10	50	580	185	310	80	1155	

able to judge will advise amendments, so that at least an approximately correct conclusion may be reached. Table IX. is based upon the examples existing and the conditions prevailing in London.

In conclusion the author would point out, particularly as regards the traffic in the central area, that the present congestion clearly indicates the need of a system superior to both 'buses and trams. The very existence of these facilities demonstrates their superiority over Tube Railways *in respect of the preponderating short-haul traffic.* The investigation set forth in this paper proves beyond doubt that the average length of journey on surface facilities throughout London is very short—not exceeding 1½ miles. In the central area the average certainly does not exceed one mile. The volume of this short-haul traffic appears to average for all London about 5,000,000 "fares" per route mile per annum, so that it seems quite probable that the volume per route mile along such thoroughfares as Oxford Street and the Strand is fully 15,000,000 "fares" per annum—and might easily be 20,000,000 "fares" per route mile per annum, quite apart from the existing sub-surface traffic. These journeys are made at distressingly low effective speed involving colossal time waste, to say nothing of other inconveniences and the accidents involved. The fact that there are about 12,000 taxi-cabs operating, mostly in the central area, is strong evidence that the public finds higher effective speed essential even though it costs at least 8d. per ridden mile. What then of the future ?

The provision of adequate facilities to meet requirements in the most economical and efficient manner is essential to the continuance of prosperity. The development of London as a port, as an industrial district and as a commercial centre, each of first magnitude in all the world, is *even now* most seriously handicapped by its lack of *cheap and effectively rapid* transport facilities. This may seem, in view of existing provisions and staggering returns, a ridiculous statement to make ; nevertheless it is perfectly true, and the sooner London realises it, the better for every subject of the Empire.

Consider for a moment the direction in which transport developments are tending. On every hand strenuous efforts are being made towards continuity of service, but these efforts are seriously baulked by the inherent limitations due to the characteristic "intermittency" of all present systems.* The approach to the ideal is involving the multiplication of small independent units and consequently an increase of the labour element in operation. This surely is not towards cheaper transport? At least in the abstract this is wrong, London can ill spare intelligent men for the distracting work—scarcely elevating—of driving buses or cabs. The welfare of a community necessitates that its brains and physique should be directed to more valuable occupations—it needs *producers*. The author is somewhat astonished that the policy of even the motor trade press is so vigorously directed to the support of motor 'buses. Surely the motor trade (which builds no 'buses for the L.G.O.C.) would benefit to a greater extent by freeing the 20,000,000 gallons of petrol, annually consumed by 'buses and cabs in London, for better service in other directions.

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* See Journal of The Society of Engineers (Inc.), 1912, p. 121 : paper on "Intermittency : Its Effect in Limiting Electric Traction for City and Suburban Service." The effect of intermittency on 'bus and tram services is even more detrimental than on railways.

But how, it may be asked, is this to be accomplished? The author ventures an answer which he submits as comprising the key to the solution of the London traffic problem. First, complete the L.C.C. tramway system in the outskirts, making the operation of 'buses (or any other system which cannot be proved to give cheaper and better transport) illegal on municipal tram routes for a period of say 10 years, or such period as would be sufficient to recover the capital sunk—relegating existing 'buses to the outer suburban districts and paying an indemnity to the Traffic Trust for rights established by custom. Secondly, equip the central area with a complete system of sub-surface transit facilities on the *continuous plan of operation*. In other words, take the full stride into the sphere of actual continuous service, where all would be calm, free from distressing turmoil, time-wasting stops and jerky starts, and where transit would at once be safe, cheap and effectively rapid. Have not the numerous escalators now at work in London proved the feasibility of continuous transit? Does the continuous plan involve the slightest danger even for the proverbial old lady with her basket of apples? Is it not inconceivable that the 99·9% of Londoners who are agile enough to escape being killed by motor 'buses, would be unable to mount and dismount from a moving platform travelling at a walking pace? It is not yet realised that continuous transit is a fully proved and admittedly feasible proposition.* The 3-speed moving platform in public service at the Paris Exposition 1900 and subsequent exhibitions carried 12,000,000 passengers, who demonstrated their ability to negotiate a speed difference of 3 miles per hour, at least 72,000,000 times *without a single accident*. The author explained in his recent paper before the Society of Arts,† why the multiple speed moving platform system has not been generally adopted—it was too

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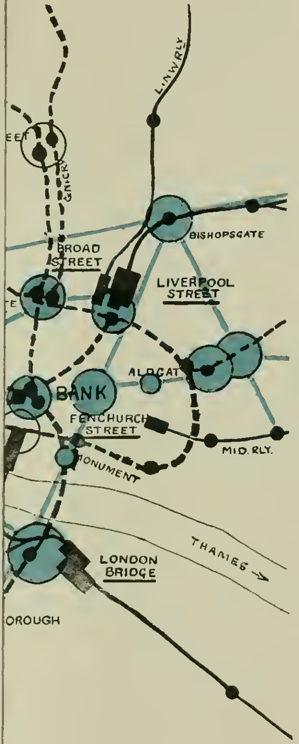
* See report of New York City Commission appointed to consider feasibility of continuous transport.

† Journal of The Royal Society of Arts, Vol. XL., No. 3082.

LEW

Society of Engineers (Incorporated),

February, 1913.



Adkins-Lewis system.
et. The large circles
given by dotted lines

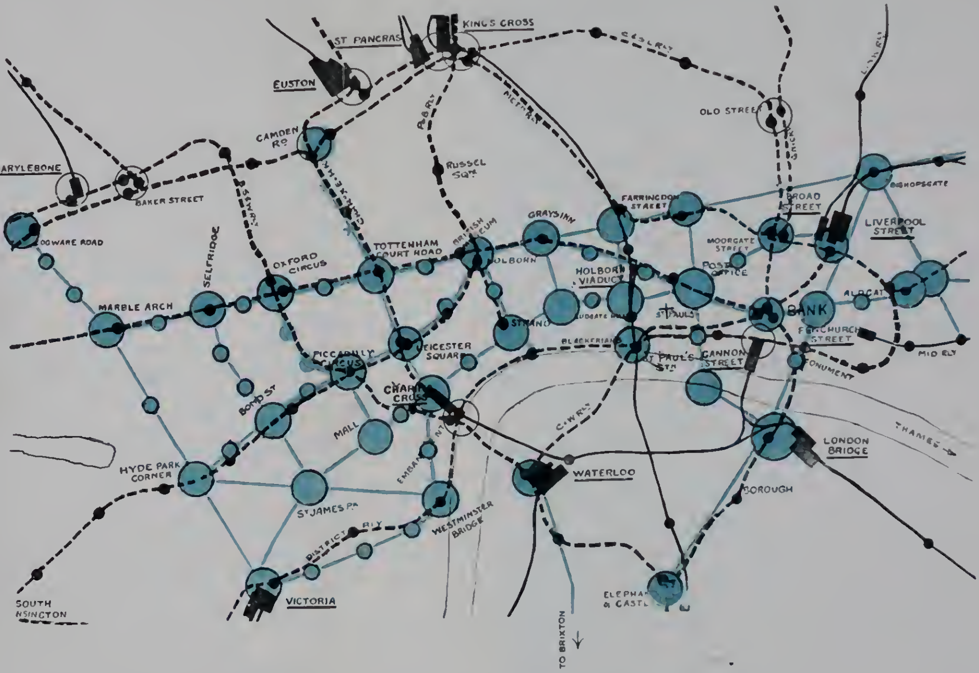


FIG. 6.—Diagrammatic plan of Central area, shewing suggested sub-surface facilities. Adkins-Lewis system. Schedule speed 16 m.p.h. with stations 440 yards apart and within 30 seconds access of street. The large circles indicate junctions. The effective door-to-door speeds attainable by this equipment are given by dotted lines in Fig. 1.

cumbersome and costly. He at the same time partially explained the Adkins-Lewis System, which in the opinion of the several leading engineers,* who have fully and quite independently investigated the system in detail, is a sound proposition from every point of view, and which the author now respectfully submits is what the central area needs on the lines indicated more or less diagrammatically in Fig. 6.

This equipment is a practical proposition, since there *is sub-surface space available*—notwithstanding superficial imaginings to the contrary. It would ensure transit, within the central area at a uniform fare of one halfpenny for any distance, and yet pay handsome dividends, if the capitalization be £500,000 a mile, which figure appears to be nearly double the actual cost.† It would enable Londoners to get about town at twice the effective speed possible by present facilities (see dotted line in Fig. 1). It would practically wipe 'buses and cabs out of the central area, since these could not compete in price or speed, whilst it would provide, at less cost, the desired interconnections between tramway terminals located in the outskirts on the fringe of the central area. There are other possibilities, which, however, need not be considered in this paper, but it is hoped that those given are sufficient to warrant attention. Where, however, is the Board or other organisation whose duty it is to look out for and encourage improved facilities with a view to the future? It is recognised that the Adkins-Lewis System must first be put to public trial on full size scale. Its originators are unable to proceed for the present with this, the next and admittedly essential step, for the want of a suitable site, since the L.C.C. cannot grant the use of the Aldwych site for more than three months, which of course is an insufficient period.

Whilst the author would appreciate any helpful suggestions regarding the Adkins-Lewis proposition, he would prefer that the discussion of this paper be confined to the Bus *v.* Tram controversy, since that is a matter of the greatest and most immediate importance to London.

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* Amongst these the following members of the Institution of Civil Engineers may be mentioned :—E. R. Calthrop, H. M. Hobart, Capt. H. Riall Sankey, R.E. (ret.), Wilfrid Stokes.

† The actual cost of the complete equipment per double track route mile at capacity of 12,000 seats per hour in each direction, 4 stations per mile and 16 m.p.h. schedule speed, would be only £75,000 per mile. The space required to accommodate the equipment is small. If necessary there could be five or six stations per mile, and this would not seriously reduce the effective speed.

APPENDIX I.

Interesting facts concerning London's Surface Passenger Traffic. Approximate data.

Annual Receipts of 'Buses and Trams aggregate	£7,000,000
No. of 'Bus and Tram rides taken annually	1,400,000,000
,, ,, ,, per head of Population	200
Average length of ride, over all London	1½ miles
Amount of money spent annually per head of population in 'Bus and Tram rides	£1
Amount of time spent annually per head of population in riding 300 miles apiece on 'Buses and Trams	4 days of 8 hrs. each
Amount of time spent annually per head of population in waiting for 'Buses and Trams, and in waiting to cross congested streets	3 days of 8 hrs. each
Losses due to slow and costly transit, traffic delays, and incidental damages	incalculable

APPENDIX II.

Motor 'Bus, Petrol, L.G.O. type "B," 34 *seats.*

Estimated Gross Cost per 'bus mile, on basis of 35,000 mileage per 'bus per annum, and an average of 2,000 'buses in service, out of 2,500 'buses in stock.

N.B.—All charges (excepting income tax and interest on capital) for engineering, and coach-building works, such as depreciation on plant and property, rent, rates and taxes, and other establishment and administration charges, are included in capital cost per 'bus, and in charges given below for repairs and renewals.

Similarly, all such charges for garages and other depôts are included in garaging charges given below :—

Summary of Gross Costs per 'Bus-mile.

	d.	d.
Fuel, etc.		
Petrol at 5⅗d. per gal. and 8 'bus-miles per gal.	0·7	
Petrol Tax at 1½d. ,, ,, ,,	0·188	
Lubricating oil and grease	0·08	
Lighting and sundries	0·032	
		1·00
Labour.		
Drivers, L.G.O. 3 Star rates	1·25	
Conductors ,, 2 ,, ...	1·00	
		2·25
Traffic.		
Supervision, inspection, tickets, clothing, etc...	0·4	
		0·4
Maintenance and Depreciation.		
Tyres	0·75	
Machinery and chassis	0·25	
Bodies and painting	0·1	
Depreciation at 20s. on £450 per 'bus	0·6	
		1·7
Garaging.		
All garaging and depôt charges..	0·75	
		0·75
General.		
Insurance and accidents	0·4	
Licensing	0·04	
Administration and sundry	0·26	
		0·7
Gross Cost per 'bus mile for average 2,000 'buses in service at 35,000 miles per 'bus per annum ..		6·8d.

N.B.—Great caution should be exercised by those who contemplate adopting motor 'buses in provincial towns in accepting figures for gross operating cost per 'bus-mile. The above figures, though possibly attainable by the L.G.O. Co. in London, operating under exceptionally favourable conditions, could not at present be attained anywhere else. On the basis of 28,000 miles per 'bus per annum the figure would probably be from 9½d. to 11½d. per 'bus-mile in provincial towns.

DISCUSSION.

The **President** moved a vote of thanks to Mr. Lewis for his paper. He supposed that one of the prime characteristics of a good paper was that it should provide matter for a first-class discussion, and that it should deal with some matters which were of immediate topical interest. He did not think that anybody would disagree with the statement that the opinions which the author had put forward were eminently controversial. As the subject of the paper had got so mixed up with political questions it would be just as well for him to emphasise the fact that the Society was not responsible for the opinions expressed by the contributors of papers. Of course, the subject of the paper was an immensely important one, as all matters connected with traffic problems must be. Money expended unnecessarily on transit was pure waste, and it was of great importance to all the population of London to be able to get to and from their work cheaply. The traffic problem was of importance in another way because it affected practically every commodity that people used.

Mr. E. Benedict said that he rose to open the discussion because the President had asked him to do so, but he did not pretend to be an expert on this subject. He, however, felt perfectly certain in his own mind that the continuous system of transport was the one which should be aimed at. It was used in Paris, and, as Mr. Lewis had said, there had not been a single accident among the 72 million users of it. The only criticism that he had ever heard against the continuous motion was the impossibility of nervous and aged people like himself getting on to a thing which was moving at three miles an hour. But, as a matter of fact, he had had to get on and off omnibuses moving at that rate, and he was not dead yet. He did not think that the consideration of the senile portion of the population should affect the convenience of the enormously greater proportion of the general public. Therefore, he thought that Mr. Yorath Lewis had worked in the right direction.

Mr. A. H. Pott said that the author had referred to a paper which he (Mr. Pott) had read at Swansea. After he had read that paper he was told that it was not quite suitable for the Swansea audience because it was obviously a paper for Londoners; but Mr. Lewis pointed out that one of the great objections to his (Mr. Pott's) paper was that it did not deal with London traffic. That showed that unless a listener could get into the mind of the writer and ascertain the object of the paper he would find it difficult to criticise the paper usefully. He agreed with the author that the first of the conclusions at which he (Mr. Pott) was supposed to have arrived in his paper were futile, as the word "large" was omitted ; but he could not think, as Mr. Lewis had stated, that the comparisons which he made were unfair.

No one more than himself would like to see the tramways of London a greater success and earning a proper profit on the capital outlay ; but, at the same time, he thought that Mr. Lewis looked at the matter from the wrong point of view. The fact was that the 'buses were popular, and, in making comparisons between 'buses and trams, they must find out why the public liked the 'buses. What the public wanted was what Mr. Lewis would like to give them—continuous transit—but that was rather far off. As Mr. Lewis advocated continuous transit, he must realise that the public liked it and would approximate to it by getting on whichever vehicle came their way first. If both 'bus and tram ran to their destination they would not wait for the tramcar if the 'bus came first, and they would not wait for the 'bus if the car came first. If, however, the 'bus went further than the tram and the passenger's destination was beyond the tram terminus, the passenger waited for the 'bus, and that was where the 'buses got such a great " pull " over the trams at present.

'Buses had made much headway in London as compared with other towns because in London there was the " 'bus paradise " through which the trams could not get. If that area could only be crossed by the trams, the conditions would be different, but at present it could not be, and in any case it was not likely that it ever would be crossed on the surface. The 'bus had come to stop and tramways had to make the best of it. His opinion, as a tramway man, was that they must, as far as possible, make the facilities that trams offered as good as those offered by 'buses, by removing all termini inside London. For that reason the tendency now was to link up all tramways,whether they were municipal or company tramways, making the routes as long as possible. Mr. Lewis made the point that many people were short riders, and, apparently, for this reason, he did not think 'buses need run long distances. He (the speaker) believed that 'bus owners preferred the long distance rider. The same result could only be achieved on tramways by through running. The 'bus paradise was the only place in which there was no other road competition with 'buses, and, naturally, as it was the centre of London, the majority of people wanted to go there. The best business of a tramway or 'bus company was to take people to their occupations and back again, and it was not surprising to find that the L.G.O.C., who were thoroughly acquainted with traffic questions, took as many 'buses as they could through the centre of London.

There were a number of other points in the paper which might be criticised if there were time. The question of halfpenny fares might easily form the subject of a paper by itself. It had been debated, he should think, in most tramway committees in England, and he should say that at present the tendency was against halfpenny fares, not because there was not a desire to give the public the best value for their money, but because of complicated details which arose in connection with such fares.

He was very much surprised to see that Mr. Lewis stated that the L.G.O.C. get their 'buses for £450. That seemed very cheap.

With regard to the petrol tax he quite agreed with what the author said about the figure per 'bus-mile. It originated, he thought, from the Board of Trade (London Traffic Department) returns. Probably, whoever got out that figure took the returns available for mileage of all the 'buses in London, which were not by any means, at that time, all L.G.O.C. 'buses, and took the total tax paid on petrol for 'buses. 'Buses now used less petrol.

On page 44 the author said, "It is obvious that the electric tram, even when laid down in the costliest manner, can furnish passenger transport at fare rates which 'buses cannot approach even under more favourable conditions." He would be glad if the author would explain that a little more. At present the most costly tramway in this country was the London County Council conduit system. He thought it rather rash to suggest that the L.C.C. conduit trams anywhere, even in outlying parts, could make more money than 'buses.

Mr. R. W. A. Brewer said that the author had a bias in favour of tramways that detracted very much from the value of the paper. London could not be compared with any other city in the world, on account of the way it was laid out. One could not conceive trams running through the City of London, for anybody who had experience of travelling about the roads of London and other towns knew how a tramway system impeded the rest of the traffic. The author was misleading in one place where he calculated the impedance of a vehicle by the number of square yards of road surface which it occupied. A 'bus by reason of its area did not create anything like the impedance that a tramcar created. Tram lines in the middle of a road reduced the carrying capacity of the road by at least 50 per cent.

The author mentioned a rate of fourpence per mile per passenger in the city. Undoubtedly the time of such a passenger was worth a great deal more. The 'bus cost through the city was naturally greater because the consumption of time and fuel was greater, and the fares were higher in proportion. A short ride in the city was often worth a penny on account of the time saved.

If a passenger were travelling a short distance, he would take the nearest vehicle, and for a long distance it paid to go a few minutes out of the way to take a train. As the previous speaker had said, people would go in 'buses because they liked them, and 'buses in the ordinary way were much more rapid than trams.

He failed to see why the author advocated an increase in the petrol tax except from the point of view of one who was interested in tramways. They paid quite enough for petrol now, and one form of transit should not be taxed more than another.

With regard to the " 'bus paradise " the 'bus was the only vehicle that could conveniently go through the city. It was the most mobile vehicle that they had, and, on the author's own showing, seated the greatest number of people in proportion to its rated capacity in actual practice. Anybody who liked to stand on the Embankment would see during the greater part of the day streams of empty trams, or trams with only one or two people in them, although great expenditure and inconvenience had been incurred in order to allow the trams to run on the Embankment.

He could not see why the author put down everything in connection with 'buses as bad and everything in connection with some other system as good. He spoke of the smell and heat ejected from a 'bus; but the modern carburettor was such that the percentage of carbonic oxide coming from the exhaust was very seldom as much as 1 per cent. by volume of the total gases ejected. A few years ago they were accustomed to obtaining 2 or 3 per cent. of carbonic oxide from the exhaust, but that was not the case now. With regard to noise, could anything be more noisy than a tram, especially if the track was badly laid? Notoriously the track on the Uxbridge Road was deafening by reason of the bad joints, and, he supposed, the bad construction of the tram undercarriage. With regard to congestion, two trams would occupy the centre of a road and allow room for only one stream of traffic at each side, whereas, when two 'buses stopped at the kerb, there was room for a great dealt more than that. Where the streets were narrow, as at Brentford, for instance, the presence of trams was a scandal.

On page 45 the author advocated a higher effective speed, but obviously that could not be obtained throughout the greater part of London by the use of a tramcar that weighed ten or more tons. A mass of that size could not maintain as high an effective speed as a 'bus weighing about three and a half tons. Furthermore, owing to the state of London traffic a tram had to hang about in slowly moving traffic, and it had to stop at certain places. The congestion and entire stoppage due to the failure of one tram on a system was too well known to call for remark.

He did not agree with the author that the acceleration of a tram was greater than that of a 'bus.

Why did the author on page 47 speak of practically wiping out 'buses and taxicabs ?—— because after all they were things that the public would take. They had to get along quickly, and the 'buses and the taxicabs in London were examples of some of the best means that he knew for street traffic in congested areas.

With regard to fares, the penny fare was not at all bad. In New York they had to pay 2½d. for any distance. They could go a long distance for a nickel, but the majority of people went only very short distances.

Trams had had a long innings and were now out of date for many purposes. It was only on account of the success of the motor 'bus during the last two years that tramway enthusiasts had cried out about competition.

In Paris, where a tramway system was being installed at great expense and inconvenience, many doubts had been already expressed as to the wisdom of this undertaking in view of the development of more up-to-date methods of locomotion.

Mr. Stephen Sellon said that the paper at its conclusion gave the reason why it had been read. It had nothing to do with 'buses or trams, but was concerned with the development of the Adkins-Lewis system as a proper substitute. This system the author suggested should be adopted for the whole central area of London, and the unfortunate trams and 'buses were to have what they could pick up outside. That would be indeed " Paradise Lost."

Let them suppose that he lived in a street adjacent to a main road which was served by tram, by motor 'bus, and by the Adkins-Lewis system, and he wanted to get to his office, and it took him four minutes to get to the tram, four minutes to the 'bus, and four minutes to the Adkins-Lewis system. When he reached the thoroughfare in which these systems were competing he could put up his hand and stop the 'bus, but if he chose the Adkins-Lewis system he had to walk to the nearest station, and then he had to run the risk of breaking his neck as he got in. He thought that it was reasonable to ask the author to reconsider his speeds, because to tell tramway and motor 'bus advocates, that four miles an hour was the effective speed of vehicles in London streets was absurd, especially when this effective speed was arrived at with an imaginary figure for the average distance the passenger had to walk.

He should like to mention another matter, and that was the continual call for reduction of fares. Was there anything more senseless than to assume that if a person wanted to go a mile for the purpose of business he could not afford to pay a penny for it ? The great curse of the municipal systems of this country was that they had been forced to adopt halfpenny fares in some cases merely because workmen said, " These tramways are supported by the ratepayers, and we do not see why we should not go for a halfpenny, whether they pay or not." If they carried out that principle they might just as well go to the absurdity of carrying the workmen for nothing.

The whole difficulty was that in London they were languishing for want of a Central Board. No one could say that competition was not absolutely and essentially necessary. It was absurd to say that if there was a tramway in a street it was not to be competed with by a better system if it could be contrived. But the competition must be fair competition. Unfair competition occurred when a motor 'bus competition could be set up without like conditions. A tramway was a statutory undertaking which was often forced to do large widenings at immense cost. Tramways had to comply with Board of Trade conditions and to maintain the road, none of which things the motor 'bus had to do. Let such a body as a Traffic Board be the governing body to decide what powers and what obligations should be given to trams, to 'buses, or even to the Adkins-Lewis System. When they had fair competition they could use the best system.

With regard to shallow subways, if they had read the evidence upon the subject was it not clear that there was an enormous number of streets in the central area where the traffic was heavy and where a shallow subway could not possibly be placed because the cost would be excessive ? £500,000 a mile was a lot to make up in fares. They found that, even if a tramway cost but £15,000 a mile to construct, the cost was a burden upon it, especially with the cost of widenings added.

He was sure that the capital expenditure on the system for London streets would be too great for financial success.

Mr. H. H. Gordon said that he agreed with Mr. Pott that through-running in the central area was absolutely necessary if they were to achieve any system of transit which would adequately serve public needs. In his opinion any system of inter-urban transit must be continuous. The failure of the tramway system in London was due to its dissociated character : they had not one tramway system but a number.

Let them assume for a moment that the L.G.O.C. was asked to work its omnibus service under the same conditions as those now governing the London tramway service. Under these conditions if the company ran an omnibus in Westminster and wanted to go into the City of London they would have to get the consent of the City of London before they could do so ;

and if they wished to go from the City to a suburban borough they would first have to get the consent of that borough. The trouble, as Mr. Sellon had pointed out, was that there was no central authority in London to control the traffic. Tramways had 29 controlling authorities in London, and he thought that immediately surrounding London there were 400 authorities that had powers with regard to highways and that the tramways had to placate. Motor 'buses were under no control as to the routes they chose ; it was clear therefore, that the handicap on tramways was so severe as to make it almost impossible to conduct an efficient tramways service.

Universal experience had proved that trams could carry large bodies of passengers along well established routes at a cheaper rate than any system of self-propelled vehicle. Where they had well defined routes justifying the capital expenditure on tramways, and where they had a steady volume of traffic, trams would continue to provide, as they had provided in the past, the cheapest form of passenger locomotion in great urban centres.

He, as a member of the Improvements Committee of the London County Council, was well aware of the constant demands that were being made for the widening of thoroughfares because of the danger created by motor omnibuses and other forms of motor traction.

A point had been made of the fact that the motor 'bus was very much more fully loaded than the tramcar during certain portions of the day. He thought care should be taken in using that argument when attempting to prove that the motor 'bus was a superior vehicle. The number of tramcars that were employed in London was determined absolutely and solely by the workmen's traffic in the early morning and late evening, when practically every tramcar running in London was loaded to the full. The motor omnibus was not designed for such traffic, and in many places did not start before 8 a.m., when the heavy workmen's traffic was over till the evening, so that smaller vehicles were employed. A greater proportion of their seating capacity was filled during the rest of the day in certain areas, but if they were to attempt to carry the enormous workmen's traffic in the morning their average seating capacity would be less utilised than was that of the tramcar.

Another reason why motor 'buses used a larger proportion of their seating capacity than tramcars was that a traffic paradise existed in London, as Mr. Lewis had pointed out. In that paradise the traffic was continuous, and had the effect of masking the real circumstances in other parts of London. He had had observations made in various parts of London, north, east, and south west, and not in the traffic paradise ; and had found that the average number of passengers carried in motor omnibuses was 6½, while the average number carried by tramcars was 18. In other words, in the suburbs where only tramcars were allowed to run, their seating capacity was far more fully utilised than was that of the motor 'buses. The greater utilisation of the seating capacity of motor 'buses was entirely due to the fact that certain rich regions were exclusively reserved for them.

Objection had been taken to any increase in the price of petrol. People who were fortunate enough to have motor cars had to pay 1s. 7d. a gallon, and there was a dispute in the taxicab industry at the present moment because 1s. 1d. a gallon was asked for petrol. He wished that Mr. Brewer would tell them what the L.G.O.C. were now paying for their petrol. He ventured to think that, if it was in the neighbourhood of 5½d. a gallon, they really ought not to object to a slightly added burden, seeing that other members of the community had to pay much more.

The real point in connection with motor 'buses and tramcars resolved itself into the consideration of an elementary principle, viz., whether a flexible or an inflexible system of traction was the system which ought to be employed in urban centres. Advocates of motor 'buses said that what was wanted was the most flexible system that could be obtained and that tramcars with their rigidity were a curse to the whole transit system in a great city. With all respect to those persons he must strongly urge that flexible traction was unsuited to such a case. They all knew that the first law of motion was that a body would move in a straight line unless external forces were presented to cause a deviation from that line. On an open road the motorist took the middle of the roadway and kept as straight a course as the tramcar on rails. If an obstacle occurred then the motor driver used the flexibility of his vehicle to avoid it. In other words, flexibility of traction was a palliative, but not an object to be aimed at any more than the taking of medicine. In a street like Fleet Street they had traffic flowing in equal volumes in both directions. He would like those who had not considered the question to make the practical experiment of going in a motor 'bus and noting how frequently in crowded traffic centres the utilisation of flexibility resulted in the retardation of traffic coming in the reverse direction. The Advisory Board of Engineers to the Traffic Commission came to the conclusion, strange as it might seem at first, that the very flexibility which was said to be the chief virtue of the motor omnibus was one of the direct causes of the congestion existing in the roads of our cities. There could be no doubt whatever that flexible traction was dangerous traction, and the more flexible the traction the greater the danger.

The Traffic Branch of the Board of Trade had given certain co-efficients to various types of vehicles. Motorists called them co-efficients of obstruction, but they were nothing of the kind. The result appeared to be that the higher the so-called co-efficient of obstruction the fewer was the number of accidents, and the lower the co-efficient the more the accidents. Evidence had been given before the Select Committee on Motor Traffic as to the number of accidents which were occurring in London. Sir Edward Henry, the Commissioner of Police, was asked by the Chairman of that Committee how the large number of accidents could be got rid of, and he replied, " I think that the ideal system of traffic and transit in any great city is a system of transit where all vehicles have a uniform speed." If they had a uniform speed what became of flexibility of traction? It was ruled out. They all knew that the carrying capacity of a roadway was enormously increased where the traffic was pursuing its way in an even course and at regular speeds. It was true that Sir Edward Henry's suggestion could not be carried out, nor was it desirable to have a uniform speed, but they could approximate to it to the extent of insisting on all slow-going traffic keeping to the kerb, that would greatly relieve congestion.

If traffic under Sir Edward Henry's ideal conditions was carried on by means of motor omnibuses, the liability to accident from mechanical defects and from skidding would still largely remain, but it would not be met with to anything like the same extent in the case of tramways. He thought that tramways would prove in London, as they had proved in all other parts of the world, to be the most efficient system of transit, if they were given a fair chance of showing what they were capable of doing.

Mr. C. T. A. Hanssen said that the real difficulties of London traffic had not been pointed out. London traffic differed from that of all other cities, except, perhaps, New York, in that the whole of it was concentrated in a few hours in the morning and the evening. They had to arrange the plant for a very much larger traffic than the average, six or seven times as large he believed, and it was therefore difficult to make such a traffic pay. A visit to any tram terminus in the morning or evening would enable one to see what a wild rush there was for seats. As Mr. Gordon had pointed out, the motor 'buses did not cater for this traffic-rush, and the plant could be adjusted for the mean traffic so as to obtain better results for the shareholders.

He thought that a great deal could be done to make the tramcars more popular than they were at present. For instance fixed stopping places were a mistake. People in London were anxious to save time and wished to be put down exactly at the place to which they were going. One reason why 'buses were popular was that they would stop wherever a passenger wanted to get in or out. He also thought that the regulations against overcrowding were far too stringent and might well be relaxed a little, so that people might be allowed to stand inside, especially on wet nights and after temporary breakdowns. In St. Petersburg he had counted 20 extra passengers on the back platform, 25 standing inside and an additional 10 on the driver's platform and nobody seemed any the worse for it.

He thought too that if transfer tickets were issued more extensively than at present, they would popularise tramways a great deal. The authorities in London seemed to be afraid of transfer tickets, which were a great convenience to the public. In Copenhagen it was possible to travel a distance of nearly 10 miles with a transfer ticket costing less than 1½d.

He quite agreed with the author, that the proper way to deal with heavy traffic was by tramways. Their introduction into London had been a great boon to the public, and it would be most serious if they were in any way hindered or discontinued.

Mr. H. Conradi said that tramways should not be a municipal, but a private service. Municipalities and Government Departments should be trustees of the ratepayers' money and not competitors in the industrial world. They had got plenty of money work with, out of the rates, but it was not not always profitably employed.

He thought that a reduction in fares would increase the number of passengers and consequently the number of motor 'buses. Motor 'buses, like tramways, had a certain service to perform. Both were useful and could work harmoniously together, but unfortunately the motor 'bus caused many accidents In view of this he had recently designed a life-guard which he hoped to be able to bring before the notice of the Society at a later date.

Mr. J. F. Jodrell Reynolds contributed the following remarks in writing :—

The 'Bus *v.* Tram controversy resolves itself into a consideration of the merits of a rigid as against a flexible system of surface transport. Given a sufficient traffic density, the rigid system is probably the better as regards speed and cost of working and may be considered preferable provided that other conditions allow of its use. The experience gained by the writer when he was in charge of the office staff to the Advisory Board of Engineers to the Royal Commission on London Traffic, has convinced him that the conditions in London do not admit of the extension of the L.C.C. or other tramways into the central area, beyond a very limited extent.

The London traffic problem is not comparable to similar problems in other cities. The motor 'bus appears to be the outcome of the special conditions that prevail in London, and the author has hardly done justice to the improvement they have afforded in transport facilities. Whether the fares charged are unduly high is another matter, and is only of indirect interest to engineers.

Considering the present congestion at many tramway junctions and crossings, it does not appear that, even if all 'buses were removed from tramway routes, it would be possible to work the additional cars required, at least during "crush" hours. The forthcoming introduction of trailer-cars will be watched with much interest.

The author's solution of the traffic problem,—to equip the whole of the central area with the Adkins-Lewis system of transport, fed at its outskirts by trams, which in their turn, are to be fed by motor 'buses—does not appear to be a satisfactory one. It would necessitate "combination journeys" involving two or more changes, which changes (as the author shews by Fig. 2) are one of the greatest causes of delay. The ideal transport system must always be from "point-to-point" without a change. It is probable that no single system will ever be evolved that will suit the central area of London, and that a dual system will always be required, consisting for short journeys of the best surface system suitable to the locality and for longer distances of a high-speed system (in a subway or overhead) with stations at such distances apart as will enable a high average speed to be maintained. (See a paper by the writer, read before the Civil and Mechanical Engineers' Society, 4th Feb., 1904).

The system of marks suggested in Table IX. is very ingenious and, on the whole, the author is fair as between the 'bus and the tram; but, when he introduces the system with which his name is associated, he is comparing an underground system with two surface systems, and to be fair he should give marks for a tube line. Taking this Table in detail:—Col. 9 applies to bad weather only. Col. 16, as regards his own system, remains to be proved. Col. 22, street congestion must vary with locality. One cannot imagine a tramway along Fleet Street, or even some parts of Oxford Street. The same remark applies to Col. 30. In fairness to the 'bus, additional columns should be given, say 8A, for "Point-to-point accessibility"; and say 8B, for "Liability to delays from obstructions." A derailment, break-down or fire causes far more delay in the case of a tram than of a 'bus. Col. 28 certainly gives marks for "Flexibility," but credit should be given from the "Passengers' aspect."

After all the fact remains that, as conditions are at present the 'bus can go to many parts of the central area where the tram could not ; also the present petrol motor 'bus may not be the last word in the construction of the flexible public vehicle.

The writer has been favourably impressed with what he has read concerning the Adkins-Lewis Traction System, and hopes it will soon be possible to demonstrate it on a large scale.

REPLY.

Mr. Yorath Lewis in reply said the discussion had deepened his impression that the importance of really cheap and effectively rapid transit was altogether inadequately realized. If the London Transport Association, which he had ventured to suggest, did nothing more than conduct an educational campaign with a view to elucidating the undoubted fact that nothing is of greater importance to the community, it would serve a most useful purpose. But it could easily do a great deal more. He, however, could not dwell on the possibilities of such an Association at the moment, though he hoped the suggestion would bear fruit in the near future. He considered that if those who repeatedly called for an impossible traffic tribunal would genuinely collaborate with a few independent public spirited men in taking the initial steps towards the formation of such an organization, London would soon be on the road to practical solutions of many of her traffic problems and others dependent upon them. At present, as was upon every hand apparent, and as even the discussion had shown, progress was staunched by ignorance of the real conditions and requirements and by various subtle influences which were working in private and party interests. He resented the allegations that he was biased in favour of trams, that he desired to thwart the legitimate operations of the so-called traffic trust and its 'buses, and that his sole object in contributing to the consideration of the London Traffic Problem was the development of the Adkins-Lewis system. As to the latter, he frankly acknowledged that if he had not seen in that, or in that direction, a possible solution of some of the difficulties, he would not have devoted so much study either to its development or to the requirements which it was designed to meet. It was not true that that was his sole object. Even if it were, would that be a valid reason why he should remain silent ? He wanted in a humble way to do something useful for the benefit of the community, and being absolutely convinced that he could not work in a more fruitful direction than towards really cheap and effectively rapid transit, which he was satisfied lay only in recourse to the continuous plan of operation, he felt justified in asking his critics to take a broader minded view of his efforts. Mr. Adkins and he had always felt that their chances of pecuniary gain from the invention of the Adkins-Lewis system were decidedly remote, but this had not deterred them from endeavouring to open the door to progress. They would be the first to make way for a better scheme and would rest content if they could feel that their efforts had contributed to higher attainments in the great field of transportation.

He was glad to have the encouragement of such an able and experienced transport engineer as Mr. Benedict, whose opinion of what the future demands is worthy of note. He thanked Mr. Pott for the courteous remarks he had made in reply to the somewhat severe criticism he (the author) had, not without regret, felt bound to pass upon Mr. Pott's Swansea paper. He had looked at the matter from the view point of cheap and effectively rapid transit. Mr. Pott surely did not think that that was the wrong aspect to take. Even *The Times*, had admitted that to be the correct view, as the following extract showed: "The form of locomotion which is found to be the best, the cheapest and the quickest, not only ought to, but must inevitably prevail." Mr. Pott's explanation of what was termed the "popularity" of the motor 'bus, constituted a strong argument for running the trams through the central area. He quite agreed that the running of a 'bus between successive trams was appreciated by the public as a nearer approach to continuous service. Carried to its logical conclusion, still smaller vehicles should be run between successive 'buses—say coolie driven perambulators, to which the late Sir Clifton Robinson likened the motor 'bus. He considered the parrot cry "The 'bus had come to stop" would largely die out if only tramway men would not be so prone to throw up the sponge. As to Mr. Pott's notions about long distance 'bus traffic, the figures given in the tables clearly revealed facts which pointed indisputably in the opposite direction. It might be that the Traffic Trust would now try to develop longer haul 'bus traffic,—their sub-surface facilities were getting overloaded, but people would still want to get to and from home at higher speeds than were possible by 'bus and tram, as shown in Fig. 3. The cost of a 'bus given in Appendix II. as £450 would not be too low under the manufacturing conditions set forth and as established by the L.G.O.C. This figure worked out at £112 per ton, which was considerably higher than the cost of even complicated electric trains built by an outside concern. He did not say L.C.C. trams could make more money than 'buses as at present operated. The present huge 'bus profits were entirely due to high fare rates and their monopoly in the central area, combined with exceptionally favourable conditions of operation. L.C.C. trams even to-day paid their way, whilst labouring under infinitely more severe conditions, and whilst serving the public to a much wider extent and at 36% less cost. Mr. Pott would find that on the whole the 'buses considered on basis of cost per passenger mile, were fully 60% more expensive to the travelling public than the trams.*

In reply to Mr. Brewer, the author remarked that such an enthusiastic motorist had been fairly well replied to by the equally enthusiastic tramway exponent Mr. Gordon, and that he could hardly expect any genuine independent student of the London Traffic Problem to pay attention to his distinctly biased remarks. He would remind Mr. Brewer that in New York the universal 5 cent fare (equivalent to about one penny in London) enabled one to journey anywhere and any distance up to 20 miles at a schedule speed of 15 to 20 miles per hour. If Mr. Brewer was quite content that Londoners should pay for their numerous little 'bus rides at the rate of 2d. 3d., or even 4d. per mile, why did he object to an increase of the petrol tax? Presumably, he would not object to pay 1s. for a loaf of bread. Mr. Brewer apparently needed to learn much about the ethics of transport. The doubt as to the wisdom of extending tramways now being carried out in Paris only existed in the minds of motor 'bus enthusiasts.

He would remind Mr. Stephen Sellon that the "Paradise Lost" to the 'buses might well and easily be a case of "Paradise Regained" to the public. He was glad Mr. Sellon had referred to the door-to-door speed. The four mile per hour effective door-to-door speed was on the average even rather on the high side for one mile journeys on 'buses in the central area. He had never said that four miles per hour was the schedule speed of 'buses; that was between 7½-8 miles per hour. Let him, or anyone else, make a few tests from and to office doors 1, 1½ and 2 miles apart first along streets through which 'buses ran, and then between doors up side streets off the 'bus routes. They would find that owing to the time occupied in walking to nearest 'bus route, delays at street crossings, and waits for vehicles, that on the average the low effective speeds given in Fig. 1 were correct. If Mr. Sellon had in the case mentioned been able to travel by an Adkins-Lewis subway, he would have completed his journey in half the time, with far greater comfort and with decidedly less risk. 'Buses do not put all passengers down at the door required, even if they traverse the right street, whilst the majority of offices are off the main 'bus routes. Mr. Sellon ought to know better than to suggest that the capital cost of a system is any criterion of its value as means for the provision of cheap and rapid transit. The paper showed that though the capital cost of 'bus service was moderately low, the operating cost was at least twice as high as tram service installed in the costliest manner.

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* Since this paper was read the L.G.O.C. have for the first time begun to publish 'Bus Returns. For 1912 the receipts were £2,684,329 and the passengers carried were 487,201,629. Thus the average receipt per passenger was 1·3223d. The results closely approximate Table VI. C or D page 38. The author will deal with these returns in an article in the forthcoming issue of "The Tramway and Railway World."

In reply to Mr. Gordon, the author begged exponents of various systems to look further into the future. Even if still more 'buses were crowded into "Paradise," or if trams be also introduced into that traffic "Eldorado," neither nor even both together could possibly meet the requirements of the immediate future. There was something much greater than the welfare of any existing or future system to be attained. The situation needed consideration with broader minds, and from a higher standpoint. Mr. Gordon, like others who had not yet appreciated the significance of the analysis he had made, greatly overestimated the extent of long through journeys. The vast majority of journeys was undoubtedly extremely short, especially in the central area and immediate surroundings. The change from a continuous system to either trams or 'buses on the fringe would be nothing like so troublesome as it undoubtedly was between say a tube and a 'bus, or between a 'bus and a tram. The increased effective speed and decreased cost of transit with continuous transit facilities in the central area would far more than outweigh interchange disadvantages which were more imaginary than they would be real.

In reply to Mr. Reynolds, the author would ask him to refer to his Society of Arts paper, and to note his reply to Mr. Gordon's remarks. He agreed that he might have added other columns in Table IX. in the interest of both 'buses and trams, but if anything, these would have only made the comparison by points come out still more favourably to the tram system. He concluded by thanking the audience for their vote of thanks, and by making a brief plea for a more determined and united effort towards the attainment of better transport facilities, passenger and freight, in and around the great Metropolis.

THE SOCIETY OF ENGINEERS (INCORPORATED).

BALANCE SHEET, 31st December, 1912.

Year ended Dec. 31st, 1911. £ s. d.	Liabilities.	£ s. d.	£ s. d.
212 5 11	To Sundry Creditors		152 4 1
30 9 9	,, Subscriptions received in advance		39 19 7
69 2 7	,, Life Membership Account		84 17 7
22 5 4	,, Premium Account (Society's)		21 4 2
15 15 0	,, Special Premium Account		15 15 0
12 12 0	,, Status Prize Account		8 8 0
56 19 11	,, Benevolent Fund		56 19 11
	,, Reserve for Depreciation of Investments ..		39 15 4
	,, Accumulated Fund—		
	Balance 1st January, 1912	852 17 3	
	Less Reserve for depreciation of Investments..	39 15 4	
		813 1 11	
	Less Excess of Expenditure over Income for the year	5 10 8	
852 17 3			807 11 3
	,, Bessemer Trust Fund	154 9 6	
	Add Excess of Income over Expenditure to date	5 2 6	
159 12 6			159 12 0
	,, Nursey Memorial Fund	46 7 3	
	Less Excess of Expenditure over Income to date	1 11 0	
43 2 1			44 16 3
	,, J. Bernays' Legacy	25 0 0	
	Add Excess of Income over Expenditure to date	2 12 3	
26 14 10			27 12 3
£1,501 17 2			£1,458 15 5

Year ended Dec. 31st, 1911. £ s. d.	Assets.	£ s. d.	£ s. d.
126 14 0	By Subscriptions in arrear, estimated to realize ..		81 13 0
12 1 6	,, Admission fees in arrear		2 2 0
56 12 6	,, Sundry Debtors		26 9 8
	,, Investments—		
	£606 London and North Western Railway Co. 3% Debenture stock as per Amalgamation Account, 1st January, 1910	524 19 0	
	£300 India 3½% Stock cost	278 13 6	
524 19 0			803 12 6
	,, Office furniture as at 1st January, 1912	39 10 11	
	Less Sale of cabinet	0 15 0	
		38 15 11	
	Less Depreciation written off	3 17 7	
39 10 11			34 18 4
45 5 0	,, Library as per Amalgamation A/c.		45 5 0
	,, Stock of Transactions and Journals	39 7 6	
	,, Stock of Law Lectures at cost	3 9 8	
47 7 0			42 17 2
	,, Cash at Bank—		
	On Current Account	190 2 11	
	In Secretary's hands	8 1 10	
425 14 3			198 4 9
154 9 6	,, Bessemer Trust Fund Investment— £185 North Eastern Railway Irredeemable 3% Debenture Stock as per Amalgamation Account, 1st January, 1910 (Market price at 31st Dec., 1912, £144 6 0)		154 9 6
46 7 3	,, Nursey Memorial Fund Investment— £33 Hammersmith and City Railway Consolidated Ordinary Stock as per Amalgamation Account, 1st January, 1910 (Market price at 31st Dec., 1912, £44 14 4)		46 7 3
22 16 3	,, J. Bernays' Legacy Investment— £13 N. & S. W. Junction Railway Stock as per Amalgamation Account, 1st January, 1910 (Market price at 31st Dec., 1912, £22 13 8)		22 16 3
£1,501 17 2			£1,458 15 5

We have examined the above Balance Sheet and accompanying accounts and have obtained all the information and explanations we have required. In our opinion the Balance Sheet is properly drawn up so as to exhibit a true and correct view of the state of the Society's affairs according to the best of our information and the explanations given to us and as shewn by the books of the Society.

23, Queen Victoria Street, E.C.
25th February, 1913.

(Signed) W. B. KEEN & CO.,
Chartered Accountants.

SOCIETY'S PREMIUM ACCOUNT.

Year ended Dec. 31st, 1911. £ s. d.		£ s. d.	Year ended Dec. 31st, 1911. £ s. d.		£ s. d.
5 17 0	To Premiums	6 11 2	22 12 4	By Balance, 1st January, 1912	22 5 4
5 0 0	,, Gold Medal	5 0 0	10 10 0	,, President's Donation	10 10 0
22 5 4	,, Balance at 31st December, 1912	21 4 2			
£33 2 4		£32 15 4	£33 2 4		£32 15 4

NURSEY MEMORIAL FUND.

£ s. d.		£ s. d.	£ s. d.		£ s. d.
4 14 10	To Balance at 1st January, 1912	3 5 2	1 14 2	By Dividends	1 14 2
0 4 6	,, Printing	—	3 5 2	,, Balance at 31st December, 1912	1 11 0
£4 19 4		£3 5 2	£4 19 4		£3 5 2

BESSEMER TRUST FUND.

£ s. d.		£ s. d.	£ s. d.		£ s. d.
5 6 0	To Premium	5 5 0	5 4 6	By Balance, 1st January, 1912	5 3 0
5 3 0	,, Balance 31st December, 1912	5 2 6	5 4 6	,, Dividends	5 4 6
£10 9 0		£10 7 6	£10 9 0		£10 7 6

J. BERNAYS' LEGACY.

£ s. d.		£ s. d.	£ s. d.		£ s. d
1 14 10	To Balance 31st December, 1912	2 12 3	0 17 5	By Balance, 1st January, 1912	1 14 10
			0 17 5	,, Dividends	0 17 5
£1 14 10		£2 12 3	£1 14 10		£2 12 3

INCOME AND EXPENDITURE ACCOUNT FOR THE YEAR ENDED 31ST DECEMBER, 1912.

Year ended Dec. 31st, 1911. £ s. d.		£ s. d.	£ s. d.
	To Printing Transactions	181 14 1	
159 10 4	*Less* Sales and advertisements	76 12 0	105 2 1
11 9 1	,, Law Lectures		—
	,, Administration Expenses—		
300 0 0	Salary of Secretary	300 0 0	
85 0 0	Rent of Offices	85 0 0	
20 7 2	Fuel, Lighting and Office Cleaning	17 6 8	
82 18 3	Postage, Telegrams, Carriage and General Expenses	82 17 10	
88 5 9	Stationery and General Printing	83 0 7	
10 10 0	Audit fee	10 10 0	578 15 1
	,, Meeting Expenses—		
19 15 0	Hire of Rooms	19 19 0	
16 16 0	Reporting meetings	18 7 6	
7 12 10	Refreshments for members at Ordinary Meetings	4 19 0	43 5 6
	,, Employment Bureau—		
	County Council Fee	1 1 0	
0 11 0	*Less* Deposits forfeited	0 10 0	0 11 0
63 6 4	,, Dinner (May, 1912) Balance		24 7 7
1 10 9	,, Vacation Visits, Balance		—
6 3 6	,, Law Charges		9 1 0
4 7 11	,, Depreciation of Office furniture		3 17 7
£878 3 11			764 19 10

Year ended Dec. 31st, 1911. £ s. d.		£ s. d.	£ s. d.
	By Subscriptions for the year—		
716 16 9	*Less* amounts written off		705 4 5
35 14 0	,, Admission Fees—		
	Less amounts written off		24 13 6
8 5 3	,, Interest on Deposit		3 12 0
	,, Interest on Investments—		
	London and North Western Railway Co. 3% Debenture Stock	17 2 4	
	India 3½% Stock	4 18 10	
17 2 4			22 1 2
1 13 3	,, Income Tax Refund		—
6 6 0	,, Law Lectures, Balance		3 18 1
92 6 4	,, Balance being Excess of Expenditure over Income for the year		5 10 8
£878 3 11			£764 19 10

March 3rd, 1913.

JOHN KENNEDY, PAST PRESIDENT,
IN THE CHAIR.

DEATH OF SIR WILLIAM WHITE.

The Chairman requested the members to rise in their places and said ; I have the very painful duty of announcing the death of our dear friend, Sir William White, an Honorary Fellow and Trustee of the Society, whom I knew very well indeed and whom all of us knew by repute. He was the one who was practically the maker of the British modern ironclad ship. He rose from the ranks by his own efforts and abilities, having been brought up without any of the facilities or advantages which many people have, and he made his way in the world till he came to the very top of the tree as a naval architect. We shall miss him very much, and the British Nation will feel his loss for many a long day. I can only say, having known him for many years, that he was one of the most charming men that anyone ever met.

PRESENTATION OF PREMIUMS.

Mr. Kennedy having announced that Professor HERBERT CHATLEY, the winner of the Bessemer Premium, was in China and that his premium would be sent on to him, then presented the other premiums awarded by the Council for papers published in the JOURNAL during the year 1912, as follows :

The President's Gold Medal to Mr. WM. P. DURTNALL for his paper on " The Generation and Electrical Transmission of Power for Marine Transportation."

The Clarke Premium, value £5 5s. 0d. to Mr. GERALD O. CASE, for his paper on " Ligno-Concrete."

The Bernays' Premium, value £2 2s. 0d. to Mr. J. P. HARRIS, for his paper on " The Construction of a London County Council Low Level Sewer from Battersea to Deptford."

A Society's Premium, value £2 2s. 0d. to Mr. PERCY J. WALDRAM, for his paper on " Test Deflections in Reinforced Concrete."

The thanks of the Society were expressed to the following who had presented papers during last year ; Mr. Henry C. Adams, Mr. G. Noble Fell, Professor Frank H. Hummel, Mr. Wm. Yorath Lewis, Mr. Ernest R. Matthews, and Mr. Spencer Sills.

The President, Mr. ARTHUR VALON, then took the chair and delivered his

PRESIDENTIAL ADDRESS.

THE rapid development of engineering science and its application to the industrial problems of a complicated civilization has made the saying that " we are all specialists " no longer a rather exaggerated description of a general tendency, but the simple statement of an obvious fact. With inventive ingenuity and scientific knowledge brought to bear on the smallest details of every branch of engineering, the number of practicable variations in the solution of every problem is continually increasing. It is hardly to be wondered at, therefore, that the average man—a convenient abstraction even if he does not exist—finds it ever more difficult to practise in more than one branch, or rather subdivision, of his profession. Whether this specialization is to be welcomed or to be deplored depends, of course, on its effects on the individual, and the community to which he belongs. So far as it results in economy, owing to the division of labour, it is an indubitable advantage, but perhaps I may be permitted to express the opinion that close specialization is rather apt to narrow a man's outlook, to make him unable to see the wood for the trees, and that this is good neither for himself nor for the community.

It is not only in engineering that there is this tendency to confine a man's energies within an ever-narrowing circle. It can be seen at work in almost, if not every, department of human activity. It is only when we reach the region of high finance that we find the same man controlling widely different industrial undertakings and roaming over a wide domain that seems to expand rather than to contract. But if we examine the matter more closely we find that here, too, specialization is at work, and that the modern business man is a specialist. He is a specialist in generalizations. He separates the fundamentals from the details, and deals with the former, taking the details on trust from others.

This is one way of reducing specialization, by taking knowledge on trust, but it is not one likely to be considered legitimate to a professional man. The essential basis of a profession is personal service, and in proportion as occupation departs from this principle it becomes less of a profession and more of a business. Besides, specialization is not thus avoided, but is merely passed on from the head of a firm to his employees. Whether it would tend to the general advantage if the supply of engineering advice and design were organized on the same basis as that of any other commodity I will not attempt to determine. It would certainly not be without effect on a question which is agitating minds at the present time—the position of engineering as a profession. That the majority of engineers are now employed in businesses conducted for commercial ends, and are consequently in a certain sense filling subordinate positions, has also an extremely important bearing on this question. That, however, is by the way. Whatever may be the position which an engineer occupies it is necessary that he should know his work thoroughly and therefore he must restrict the area of his studies. What is not necessary is that this area be restricted by a want of organization and co-ordination of the existing knowledge embraced within it.

The immediate cause of what may be termed over-specialization is the continually increasing mass of detailed knowledge which has to be acquired by personal experience ; and this can be diminished by reducing the number of problems to which there are practicable alternative solutions. If there are fifty different ways of doing everything that has to be done, the practitioner must know every one of them to select the best, and consequently although his knowledge is detailed, it must be smaller in extent than if he had only one standard method. New ideas are enunciated, old ideas are criticized, new processes and methods are introduced and old ones modified. In these matters—matters of opinion—each man must examine and decide for himself. A large field there must always be wherein personal experience is essential, but it does not seem either necessary or desirable that matters should remain in this field, when sufficient knowledge exists to remove them from the region of opinion and place them in the domain of reasonable certainty.

The slow process of permeation, by which the epoch-making discoveries of one generation become the commonplaces of the next, and the operation of the natural processes of the elimination of the unfit, will eventually deal effectively enough with the larger questions. In the case of discoveries which are not epoch-making, and things which are not so much unfit as superfluous, we cannot afford to wait from one generation to another. We want to quicken the natural process, and to select, to co-ordinate, and to combine the experience and knowledge which is scattered among many separate individuals. One method by which this can be, and, as a matter of fact, is being done, is by standardization. Like most things it has its characteristic dangers. If applied incautiously to matters on which opinion has not sufficiently hardened, it may be mischievous, as it might tend to damp the ardour for research and thus prevent improvement. On the other hand, a standard need not be regarded as a petrified convention, but merely as the best that existing knowledge enables us to determine. With fuller knowledge revision should always be open. The proper field for standardization is indeed so large that the probability of its misapplication is remote enough to be ignored. The advantages far outweigh the risks, for if carried to its fullest legitimate limit it would reduce much unnecessary labour, and set energies free to deal with other problems, besides conducing to that economy in production which is perhaps its highest recommendation to a commercial nation.

A large amount of most valuable work has already been done in this direction by the Engineering Standards Committee. Since 1901 they have dealt with 54 Reports and Specifications, truly a goodly list, yet more remains behind, for any engineer could draw up a list almost as long of matters which might be dealt with in his own special line. This work, if it is to be done effectively, ought to be spread over as many people as possible. Every branch association should do its share, not independently, but in conjunction with the central body. It cannot be expected that a professional man can give more than a small proportion of his time to such work if it is honorary, and therefore, although advisory committees are of the greatest use, capable men must be employed to do the actual work involved, and must be properly paid for it. Ways and means present a serious problem. It certainly does not seem fair that the whole cost should fall on the professional associations for this work, the economic advantage of which will accrue not to them but to the community. Some part of the cost of the work of the Engineering Standards Committee has, as a matter of fact, been provided by the Government, and it may be hoped that a widening view of national interests will lead to extended assistance from this source in the future.

The last twenty years have seen an unprecedented extension in the application of engineering processes and a progressive development of every form of engineering, the results of which are only comparable to those of a complete revolution. Anyone who can look back that length of time to his own pupilage must admit that the standard of knowledge and the stress of work then will bear no sort of comparison with what exists and is required at the present time. The effect of these changes on the personnel of the profession has been very great. When engineering was almost entirely a matter of practical experience, it naturally followed that professional qualification depended on this, quite exclusively of any considerations of general education. Now that the scientific principles underlying engineering practice are known, and rational methods of calculation and design are superseding those of empiricism, a complete knowledge of these principles and their application is necessary to an engineer if he is to be properly equipped for his work.

The man who works by rule of thumb, the so-called "practical man," has had his day; he did much good work, and we do well to respect his memory. The future is to a different type, but still to the practical man, one who with wide and thorough knowledge of theoretical principles is fully alive to all the actualities of practice.

Looking back through the records of our professional organizations, I find that the question of the proper education of an engineer has been a subject of discussion ever since we have had a corporate existence. So long as engineering was a craft in which individual experience was the only road to knowledge, a term of apprenticeship to a master craftsman was the natural method of education. As the body of engineering theory took shape, by the accumulation and classification of observed facts regarding the properties of matter and the discovery and application of those apparently constant sequences connecting phenomena which we, rather misleadingly I think, term natural laws, it became evident that the system of apprenticeship no longer completely met educational requirements. In a workshop or office we are occupied in dealing with concrete materialities; the methods used may include deductions from theoretical considerations, but as a rule it will be the results of theoretical investigation conducted by others and expressed either by a formula or in a generalization of some other kind.

The examination of mathematical, physical or other premisses on which a theory may be based cannot enter into the ordinary everyday work of commercial design and construction. Hence it was very often, perhaps usually, the case that at the end of a term of apprenticeship the pupil's acquaintance with the theory of engineering was only sufficient to enable him to use a few formulæ of which he might not even understand the premisses. He would therefore, quite possibly, use them in the solution of problems to which they were not applicable, with a comfortable feeling of satisfaction that he was working in accordance with the latest scientific principles. It was no wonder that the man who relied on the empiricism derived from practical experience, which was certainly scientific within its limits, was inclined to distrust all theory and to pride himself on being a practical man.

Despite this attitude, however, in the years preceding 1870, the Englishman, being a very humble-minded individual, had one of those recurrent attacks of self-distrust to which he is subject, and of which the usual symptoms include hallucinations as to the relative power and progress of other countries. It was said that the technical education of this country was so much inferior to that in other European States as to threaten seriously the industrial supremacy of Great Britain. The Institution of

Civil Engineers accordingly obtained a large amount of information, which was issued in 1870, under the title of "The Education and Status of Civil Engineers in the United Kingdom and in Foreign Countries." If this did not dispel the doubts as to the sufficiency of the education in theory generally obtained in England it did give a better idea of the relative advantages of the English system. Although the tale was, in the main, left to furnish its own moral, the following description is interesting in view of modern developments :—

> "The theoretical knowledge which may be desired is obtained either by private reading or by attendance at the scientific classes established at various educational institutions, some of which have made special provision for studies of this kind.
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> "The practical education in England is perhaps the most perfect possible, if the opportunities obtained during the pupilage are ample and the pupil properly avails himself of them ; for nothing can give a student so thorough and useful a knowledge of practical works as being actually engaged for a length of time upon them in a really working capacity ; in addition to which the habits of business and the familiarity with all subsidiary arrangements acquired in this way have a beneficial influence on the student's future career. This thorough proficiency in practical matters tends largely to compensate for—in some cases to outweigh—the deficiency in theoretical attainments ; and it is undoubtedly this, influenced in some degree by the natural self-reliance and practical common sense inherent in the English character which has given such a high standing to the profession in this country."

Since that was written the pendulum has swung far in the other direction, and sometimes it seems that disproportionately great importance is attached to theoretical knowledge and academic attainments as compared with practical experience. Perhaps it was inevitable that this should be so. We are always inclined to magnify the desirability of those qualities in which we are defective, while minimising those we possess, and the weak point in the intellectual armour of the Victorian engineer was undoubtedly on the theoretical side. As a practical man of affairs he has had few equals, and it was this, rather than technical qualifications, that enabled him to make British engineering pre-eminent all over the world. Not that his technical knowledge was to be despised ; on the contrary, he had a very complete knowledge of the practical means available to any particular end, which is of the essence of technical qualification. And he had also a fine knack of grasping the real goal of his work, and subordinating everything to it. If a river must be bridged safely without much regard to expense, he made sure, and economy was at a discount. If, on the other hand, it was a question of reducing the cost of production of some commodity, economy was pursued and æsthetics disregarded. Indeed he was, as he prided himself on being, a practical man, ready and able to deal not only with the engineering side of his work, but with every factor affecting his work, whether it were political, social, or economic.

I do not know whether this type of man is now less frequently an engineer than formerly; possibly not, as his outstanding qualities are still characteristic of prominent engineering circles. But his peculiar characteristic, the possession of a large amount of that elusive quality termed initiative, does not appear to be so typical of modern engineers. Indeed, the complaint is frequently made that the lack of it is a serious defect in the modern man generally, and we are given to understand that in this respect we compare very unfavourably with our predecessors. Whether the charge is true it would be very difficult to determine conclusively, for to compare the present with the past is rather like comparing a good photograph with a post-impressionist sketch.

Initiative, being originality in one of its manifestations, is hardly likely at any time to have been, in any great degree, a very common endowment, and it may well be that we attribute to the average man qualities that were possessed by a comparatively small number of men, who perhaps, seen through the fog of time, loom even greater than they were. Be that as it may, it is more of archæological than of actual interest, and we have too much to concern ourselves with in regard to our positive qualifications to spend overmuch time on questions of comparison. Whatever may be the relative distribution of the particular quality among the existing population, it will probably be agreed that it is a very valuable asset to the lucky individual who possesses it. It is almost indispensable to marked success in any walk in life, and its market value in some positions is greater than that of any other qualification.

As the supply of an article is generally developed as far as possible when the market value is high, it would be natural to expect, therefore, that initiative would be carefully fostered during the course of education. And so no doubt it would be were it not that, high as may be its market value, the positions in which it can be used are, in present-day industrial conditions, a small and decreasing proportion of the whole, owing to the tendency towards over-centralization. Nowadays a far larger part of the community consists of employed persons than at any former period, and although the possession of initiative is in some positions of great importance and value to the employer, it is not in general so essential as complete technical knowledge, and consequently the demand now is, in all occupations, for men who have complete technical knowledge. This, it may be said, ought not to be incompatible with the possession of initiative, but the exhibition of a quality will, in the long run, depend not so much upon its market value in a few positions as upon the demand for it in ordinary employments.

So far as engineering is concerned there has in recent years been an enormously greater increase in more or less subordinate positions, for which complete technical competence is a necessity, while initiative is only a luxury, than in those where the relative importance is reversed. That this is so is indicated by the comparative increase of the different classes of members in technical societies. Taking the Institution of Civil Engineers as an example, the number of full members in 1882 was 1,261, and of associate members 1,406. To-day (1912) the numbers are: full members 2,345, associate members 5,056; so that while in 1882 the number of associate members was 11 per cent. greater than the number of members, it is now 116 per cent. greater.

The effect on engineering education of the demand for technical attainments has been to make it imperative that the course of training should give technical excellence whatever else might be sacrificed in the process. Consequently we find that in recent years a very large amount of time has been devoted to this subject by the different professional societies. In 1903 a committee to consider the subject was appointed by the Council of the Institution of Civil Engineers, in conjunction with institutions representing various branches of engineering, and after opinions had been obtained from some ninety teachers and engineers, the committee presented their report in 1905. This report is still, I believe, the only authoritative pronouncement on the training of engineers. In that report it was recommended that the age for leaving school should be 17, that one year should then be spent on a preliminary workshop course, followed by three years' college training, and a further three years' practical training. Few will doubt that if the course laid down were conscientiously followed it should result in competent technical knowledge. On the other hand, it doubtless involves some consequences not altogether beneficial.

The future engineer, until he is twenty-one years of age, will be occupied in acquiring academic knowledge, using the word "academic" in its normal meaning and not in any derogatory sense. Now, it is a matter of common experience that men of learning are seldom men of action; that there is an apparent incompatibility between learning and doing, or it may be more accurate to say the bent of mind best able to learn is not that most likely to excel in action. And while most occupations in life consist of doing rather than knowing, this is more obviously true of engineering than any other profession. We engineers have always recognized this, for it is at the bottom of our sometimes vehemently expressed conviction of the importance of practical experience. And in spite of the popular tendency to attach a rather disproportionate value to degrees and diplomas, we still maintain that these are only evidence of knowledge (not always even that) and never of executive fitness, which is the true end and aim of an engineer's training.

I do not, of course, deny that the theory of engineering must be known thoroughly, and that probably the easiest way to learn it is to follow a continuous college course for a sufficient period ; nor do I wish to say for one moment that a University training is necessarily a bad thing, for, on the contrary, I think that it may be a very good thing ; but it lengthens the time spent under the dominant idea of learning rather than doing, and my experience is that it tends to form a habit of mind which is not altogether that best suited to the everyday work of the engineer. It is, no doubt, a very difficult matter to devise a course of training which will ensure an adequate knowledge of theory, while conserving and developing those qualities which are needed in practical work, and are best obtained by an early acquaintance with practical conditions. I am rather sorry, however, that a continuous college course has been definitely adopted. Knowledge of theory, unlike practical experience, can be very fairly tested by means of examination. There is not, therefore, the same necessity to prescribe a definite course for theoretical as for practical training. Provided the necessary knowledge is obtained, the means of acquiring it might be quite safely left to individual preference, and where it can be arranged the study of theory might proceed side by side with practical training, which is a much better system than that of dividing them into watertight compartments. There is, I think, at the present time, a danger of the undue exaltation of the purely scientific side of the profession, and it behoves us to be careful that our system of training does not produce savants rather than engineers, a result which it is well known has occurred from the high scientific training adopted by one at least of our Continental neighbours.

The view has been quite recently put forward by a gentleman engaged in scientific teaching that a four years' college course is necessary, on the ground that engineering is now one of the learned professions, and that the training must not be shorter than for other learned professions. This opinion is illuminating and interesting, as showing what is likely to happen if we allow engineering education to be too much influenced by the views of those who devote themselves to the teaching of engineering theory. First, you will observe that in speaking of the period of training, the time spent in practical work is ignored, and the college course regarded as paramount. Secondly, to regard engineering as a learned profession shows, in my opinion, a total misconception of its nature. Engineering would be much more accurately described as a craft, an ordinary craft raised to the power of *n*, if you will, but still a craft in which the ability to do something, and not the possession of learning is the test of efficiency.

For a variety of reasons, which it would take far too long to enumerate, and which would be superfluous for our present purpose, it has been the custom in this country to look upon the academic authorities not only as the proper people to determine how a subject should be taught, but also to say what subjects it is necessary to teach. The effect on the general education of the nation has been sufficiently disastrous to make us pause before accepting the same guidance. How could it be otherwise? For the first task they may have every qualification, although they are frequently appointed for the knowledge they have acquired and not for their ability to impart it ; for the second they very probably have none at all. The people who know best what the aim of education should be are those who do the everyday work of the world, and consequently know from hard experience what is wanted ; and if we are wise we shall take very good care to determine for ourselves what scientific knowledge is required by the average engineer without too much deference to purely academic opinion.

If we have devoted much time and thought to the problem of education, and have succeeded in dealing fairly effectively with it in its more immediate and objective aspects, the same cannot be said with regard to another question, the ultimate influence of which upon the welfare of the community and the profession is probably at least as great, while it is of even more pressing importance to the individual at present engaged in engineering pursuits. I refer to the organization of the profession. At first sight it seems somewhat strange to suggest a lack of professional organization, in view of the existing institutions, associations and societies which, it will be admitted, are certainly not deficient in point of number. They have, however, confined their work almost entirely to matters of education and educational qualifications. They have usually been formed originally with the object of giving their members opportunities for improving their technical attainments by the interchange of opinions and experience. The reading and discussion of papers on technical subjects being the most obvious means to this end, became consequently their chief direction of activity. A concern for the provision of technical information and for education generally, and the institution of examinations to test its results were natural developments. Some small and comparatively unimportant departures in other directions have been made, but, speaking generally, there has been no attempt to use the corporate strength of the profession to deal with those matters which the individual, by himself, cannot cope with, although they may seriously affect his pay, position, and prospects, and other things more intangible but not less real that affect his life and happiness.

There are three heads under which the most obvious, if not the whole, of a professional man's material interests may be grouped, and these three may all be included under the one word "employment." First, to obtain it; second, its remuneration; and, third, its conditions. When a man has completed his training, unless he is very fortunately circumstanced, he is immediately confronted with the problem of obtaining employment, and he finds that he is dependent, almost entirely, on his circle of acquaintances for information as to any openings which may be available. There may be plenty of opportunities for congenial work if he only knew where they were to be found, but in the absence of a recognised medium of communication between prospective employer and employed he has to be content with what happens to be nearest to hand at the moment, which may not be by any means that for which he is best suited. Frequently employment of an inferior kind at a small salary must be accepted, temporarily it is, of course, hoped, in order to provide means of subsistence until a better opening presents itself. The result is, that in many cases years are sometimes wasted before reasonably suitable employment is obtained.

It may not, of course, be possible to ensure, under all circumstances, satisfactory positions for all who may be qualified to fill them. That must depend eventually on the relation of the supply of men to the demand for their services. We can, however, by organization and co-operation, eliminate a great deal of the waste and friction which the present system entails.

The interest of the employer, whose support is necessary to the success of any scheme, lies in obtaining a man with the qualifications he requires more easily and certainly than in any other way, and it is because hitherto there has been no such inducement that employers have not made extended use of the limited facilities afforded by existing societies. That employers are quite ready to avail themselves of a system which meets their requirements reasonably is shown by the experience of one of the Universities, where an appointments board exists to recommend men desiring to enter the business world to employers having positions to offer. So successful has this board been that the number of positions open is greater than the number of men suitable to fill them. That success has, no doubt, been gained by very carefully refraining from recommending anyone unless he possessed the necessary qualifications, and this entails a fairly intimate knowledge of a man's attainments and character. In the restricted area of a University this is easily and directly obtainable. In the case of a large professional organization it presents a somewhat serious difficulty. In the one case those who make the recommendations are themselves personally acquainted with the candidates, while in the other the recommendations would have to be made through or by a permanent staff. This need not, however, prove an insuperable obstacle, given good faith on the part of those who have first-hand knowledge of those seeking appointments, and an adequate organization sufficiently decentralized to meet industrial and professional requirements.

Such an organization, if it succeeded in dealing with this question satisfactorily, would also be in an excellent position to bring the influence of the profession to bear on the questions of remuneration and conditions of employment. Naturally, recommendations would not be made where these two matters were not satisfactory, and, as has been the case in another profession with some analogy to our own, disapproval of the salary or conditions of an appointment, intimated to the members, would generally have the effect of preventing that appointment being filled, and so indirectly be successful in obtaining the amendment of objectionable features.

Another proposal which has received a good deal of attention lately would also indirectly affect those questions very materially, viz., the suggestion that, by statutory registration, engineers should be placed in a similar situation to that occupied by members of the legal and medical professions. There has arisen in recent years a widespread conviction that, while it is all very well to lay down elaborate systems of education which are believed to be necessary for those aspiring to become engineers, and to provide every opportunity for engineers in practice to keep themselves abreast of scientific progress, it is only reasonable and proper to ensure that those who have spent time, energy, and money in qualifying themselves thoroughly for their work shall not, at the end of it all, find themselves in no better position than unqualified persons who have done none of these things. The grievance is a real one, and one for which some remedy ought to be found.

It is also very generally believed that the absence of any definite compulsory standard of qualification to practise, adversely affects the standing of an engineer with regard to the community in which he lives. Naturally enough also, unqualified competition is blamed for lowering the rate of remuneration and decreasing the work available for qualified men. How far the charge is justified it would be very difficult to determine. That there is some foundation for it everybody's experience will tell them. The ability to do work is not at all the same thing as ability to get work to do, and it is indeed somewhat uncommon to find the two talents combined in the same individual. As the second is usually a condition precedent to the first, it is not difficult to imagine that anyone possessing that gift, although combined with inferior technical qualification, would be a very serious competitor to the man with the converse intellectual equipment.

It is easy to see that these troubles are such as affect the general body of professional men, rather than the leaders, and this may account for the fact that no very serious attempt has been made to deal with them, as it is difficult for anyone to realize the urgency of a question which does not touch him nearly. It must, however, be agreed that there are very many difficulties in the way of a scheme of registration. Engineering covers so wide a field that it is anything but a simple matter to say where it begins and ends, and there are branches of engineering so distinct that a man who has been educated for one might be totally incompetent to undertake the work of another.

Then again, the class of work varies enormously, and the standard of indispensable qualification varies proportionately. How is the standard to be fixed and the work defined for which a registered engineer should be employed? It is true these points would not be included in an Act of Parliament. They would have to be left to adjust themselves later. But those subject to registration would need to be defined, and the practicability of any scheme must be demonstrated before there could be any hope of its being passed.

These are only a few of the obstacles to be surmounted. In addition, it has to be shown that the public at large stand to gain, and this is not a very easy thing to bring home to a community which is inclined to be suspicious of any proposal that seems to have for its aim the constitution of a close corporation for the benefit of its members. The amount of money wasted by inefficient engineering may, in the aggregate, reach a very large sum. Unfortunately, except on the comparatively rare occasions of total failure, the waste is not evident to those outside a small circle qualified to judge.

Later on I shall endeavour to show that the welfare of our profession is vital to that of the community, and therefore if registration will assist in increasing it, there are good grounds for demanding its establishment. It can, however, I think, be accomplished only if we ourselves are united in considering it to be desirable, and our wishes are effectively presented, either by a combination of all existing institutions, or by some organization which would devote its energies to this and the other allied questions.

Apart from the baneful influence it exerts on professional status, it is probable that the basis of the complaint against unqualified competition is the objection which is naturally felt to the result of competition in general, *i.e.*, a reduction in the scale of remuneration. And this will be equally unpleasant whether it arises from qualified or unqualified competition. We may agree that the latter can and ought to be excluded. The former cannot be shut out, and is not likely to grow less as time passes without a much more rapid increase in engineering work than we have any grounds for expecting. Up to, or almost up to, the present time recruits to the closed professions particularly (but to the others also in some measure) have been, from financial and educational circumstances, drawn from a comparatively small section of the population. With the general spread and improvement in education, and the arrangements which have been made, and will no doubt be increasingly made in the future, to enable any member of the community to qualify for whatever occupation he may have the requisite aptitude, the possible number of recruits will be very materially enlarged. The effect of this is bound to be increased competition, and competition from those whose standard of living may not be nearly so high as in that circle of society from which the professions are at present filled. In these circumstances we are bound to contemplate as a practical certainty the continued fall in the standard of remuneration of professional services. No restriction due to registration will prevent this, although it may assist to do so by raising the qualifications necessary for admission. The only way that it can be effectively countered is by proper organization, which will enable the influence of the profession itself to be used in settling the terms of employment of its members.

If an example be needed of the importance to a profession of effective organization we have it to hand in the recent conflict between the medical profession and the National Executive. I am not at all concerned with the political aspects of the matter, or even with the rights and wrongs of the dispute. There can, at any rate, be no doubt that in the absence of such an organization as the British Medical Association the medical profession would have been compelled to see the existing financial basis of its operations destroyed and another substituted which the doctors themselves believed to be inimical to their interests ; not because there was any desire on the part of the Government, still less of the community, to treat the profession unjustly, but merely because there would have been no organization that could authoritatively express the views of the rank and file of the profession and conduct discussion on their behalf. What has occurred to the medical profession may, at any time, happen in one form or another to us, and I think we shall agree that it is desirable we should be prepared against that day.

The kind of organized action to which I have referred is sometimes contemptuously alluded to as trade unionism, with the obvious intention of importing prejudice into the discussion, for it does not follow that a society with some objects similar to some of those of trade unions need be conducted so as legally to become such a body. We need not, in any event, be greatly troubled at any description of our action, if we are convinced that the action itself conduces to the general good. However much we may object to the conduct of some trade unions on certain occasions, and however inconveniently their proceedings may sometimes interfere with our work, we are bound to confess that they have justified their existence. The history of trade unionism has, at all events, shown us that adequate organization is the only practicable means of preventing wages from falling to a minimum in the absence of a demand for labour greater than the available supply. That principle is as applicable to our labour as to any other kind of labour, and as the supply increases, the truth of the economic law may become unpleasantly apparent to us.

It cannot be too strongly insisted upon that such organization is protective and not aggressive. It is not calculated to injure the interests of the community at large, but on the contrary, to advance those interests. The common good is not something outside and unrelated to the individual good, but is the sum of all the individual goods. The welfare of the nation cannot be divorced from, but is dependent upon, the welfare of the units which compose it. However, what is everybody's business is nobody's business. The community does not concern itself directly for the interests of the individual, or of particular sections of the population, except in those cases where it cannot avoid doing so. All individuals and trades and professions are expected to be the guardians of their own interests, and they who are too indifferent, or too lazy, to take the trouble involved in conserving them are not likely to experience much vicarious concern on the part of others.

That the welfare of the country generally is intimately connected with the welfare of the engineering profession is fairly evident when we consider that the whole material structure of our modern civilisation is erected upon a foundation of engineering science. We are dependent, directly and indirectly, upon the results of that science for most of our luxuries, and for nearly all the necessities of existence. Without the improvement which has been made in the speed of communication and the means of transit at a low cost, together with the economy resulting from the application of mechanical processes to industry, all of which are directly due to the progress of engineering, it would be impossible for these Islands in which we live to support anything but a small part of their existing population.

It is true we are not infrequently told that the lines upon which we are proceeding are altogether wrong ones, and that real civilization would be better served by less attention to the material side and more to the intellectual and artistic. That is a matter about which it is hardly worth while arguing. It is impossible to take to the growing of corn and the tending of flocks and herds, and to emigrate the surplus population who cannot be sustained in this manner, and mechanical progress cannot even be slackened without the almost certain loss of the position which we occupy in relation to other countries, and perhaps the destruction of the British Empire itself.

The doubts expressed of the wisdom of a civilization based on industrialism arise, I think, in part from a belief that enduring national solidarity cannot be expected without the possession of a common ideal, and that such an ideal can hardly exist in the absence of a fairly equal standard of education and of existence. That is a question far too complex to argue in the time at my disposal this evening. The distribution of wealth is a very different thing from its production, and it may be that the existing distribution is not entirely equitable, but in any given proportional distribution it is perfectly clear that an increase in the amount available for distribution is of advantage to all. It cannot for a moment be maintained that the material comfort, or the intellectual level, of the mass of the population has been diminished since the application of mechanical science to industry and it seems to me that the best hope for a reduction in the hours of labour, and an increase in the amenities of existence enjoyed by the working classes will rest in the continual improvement of engineering processes. If this is true, then the interests of the community are inextricably bound up with the progress of engineering science. Now, this progress must depend on the personnel of the profession, and anything which tends to take away the attractiveness of an engineering career must also tend to diminish the supply of recruits. It may, for various reasons, not decrease the quantity, but it will inevitably adversely affect the quality, and thus deprive industry of the men upon whom progress chiefly depends.

Although I have hitherto referred to engineering as if it were directed exclusively to utilitarian ends, yet as a matter of fact much of our work has an æsthetic side of scarcely less importance. Many of the structures for which we are responsible are prominent and conspicuous objects, which are constantly in the public eye, and must have considerable influence on public taste. Their treatment, therefore, apart altogether from the practical purposes for which they are designed, is deserving of a great deal more attention than it commonly receives. A bridge or railway station, a gasholder, or even a series of large cranes frequently affect the whole character and appearance of the locality in which they are placed, while the very nature of a countryside may be radically altered by the erections consequent upon the introduction of an engineering process.

Art in relation to engineering is a fascinating subject, and its adequate treatment would require a volume to itself, but one which I am afraid is not very likely to be written just yet. I do not know that I have ever been able to discover a really satisfactory definition of art, and, unfortunately, it is not quite so simple a matter in this case as it was in that other, when an eminent statesman and man of letters said that he could not define an elephant but he knew one when he saw it. The most general definition that I have heard is that which explains art as being any means adopted for emotional expression. If we accept this, then perhaps we may define art, as applied to engineering, as the means by which an emotional feeling is aroused in a spectator from contemplation of an engineering structure. For practical purposes this definition may be still further narrowed, because there are certain limits to the range of emotions it is desirable to arouse. Some structures induce in the spectator a very definite emotion—that of horror ; but it may be concluded with a fair amount of certainty that there was no desire on the part of the designer to arouse this feeling, and we may dismiss it as an example of an application of art. The aim, where aim there is, will be to achieve beauty, or that quality possessed by an object the contemplation of which induces an emotional feeling of pleasure in the beholder.

To the general statement that beauty is a desideratum in all structures something like universal assent will probably be given. It is when we come down to the particular, as to what is or is not beautiful, that differences immediately arise. It is evident, from the definition itself, that beauty is a quality not entirely inherent in the object itself, but also dependent on the observer. The emotional feeling aroused in any person by the contemplation of any object must depend upon that person's whole intellectual content, on character, on experience, on memory. It is ordinary everyday observation that tradition alone has enormous influence on what appeals to people as beautiful. Under these circumstances, no matter what our artistic gifts may be, we are not likely ever to succeed in having our work universally accepted as beautiful. Indeed, we are in a particularly difficult position, for we are constantly experimenting with new materials and new methods of construction around which no tradition has, as yet, grown up, so that frequently we are like a man endeavouring to convey a meaning in a language of which the people to whom he is speaking have no knowledge. A steel bridge, however beautiful it might be to those who were aware of the properties of the material of which it was constructed, would not be likely to appeal to those who had hitherto been familar only with the use of stone. The whole principles of construction are different, and the steel would be almost certain to create an impression of instability. We are thus compelled to rely on our own taste. At least we may be quite sure that no enduring beauty is likely to be achieved without truth and sincerity in using the materials at our disposal in accordance with their own peculiar properties. The first essential is the most perfect adaptation of available means to the practical end in view. If within these limits we can obtain what we believe to be beauty of line, of form, and of colour, then, as others have had to do, we must leave the verdict to posterity.

As to the effect of industrial operations on the localities in which they are carried out, we have, I am afraid, not much ground for hoping that the verdict will be favourable. The responsibility for this is not one which rests entirely, or even chiefly, upon engineers. The destruction of a countryside and the evolution of urban centres from which beauty has been banished as of no account, has been dictated by economic considerations and the acquisitive instinct of mankind in general. If it is a crime it is one in which we have all shared.

How far economic considerations should be subordinated to the preservation of the amenities of a district I am not prepared to determine. That their preservation is worth considerable effort and expenditure I am convinced. In travelling through the industrial area it is plain to see how easily much of the ugliness and squalor could have been avoided. Much of it, too, appears to have been unavoidable from the fact that, unlike Athene, who sprang full armed from the brain of Zeus, our knowledge has only been built up by slow and painful degrees. We have, however, good reason to believe that the improvement of engineering will itself provide a remedy for the ills that have arisen in the course of its development to the present stage.

One other matter there is upon which our consciences are not clear, and which we cannot surely contemplate with complete satisfaction. The development of the country's economic resources has resulted in the growth of some occupations which it is not going too far to say are a disgrace to a civilized community. No doubt in time, with the improvement in the quality and area of the education obtained by the mass of the population, this evil will cure itself, because men will decline to enter those occupations. Then we shall be bound to substitute mechanical processes. In some industries a great deal has already been achieved in this direction. In the branch of industry to which I devote most of my attention, one of the operations involved labour conditions uch as I have referred to. For the last quarter of a centurya continual improvement has been going on, and at the present time there is no reason for the existence of the evil conditions which formerly obtained.

These improvements have been made, as in most similar cases, because of an accompanying economy in production. I would venture to suggest, that, where possible, such improvements should be carried out whether or not they have also the advantage of reducing the cost of output. Hitherto the development of engineering science has been directed by its almost exclusive use for economic ends. The effects, good and bad alike, upon social conditions, great as they have been, are but an indirect consequence. It is not unlikely, judging by the apparent trend of thought, that in the future all our resources will be used more directly to deal with such questions. May we not hope that by further lessening the time and labour required in production and distribution, by substituting mechanical power for brute furce, by the further utilization of waste products, and the destruction of those that are noxious, indeed, in short, by a better application of the great forces of nature to the use and convenience of man, the future progress of engineering science may enable the community to ensure a proper standard of civilized life to every one of its members.

Mr. J. W. Wilson :—Mr. President and gentlemen, it devolves upon me as senior Past-President to move a vote of thanks to our President, Mr. Valon, for the extremely interesting and earnestly thought out address that he has just delivered to us. It is not our province on an occasion like this to discuss the address as if it were an ordinary paper, but it is open to us to make one or two remarks. I am sure we all go with him, in the very important matter which he has treated in the first portion of his address. I refer to the well-worn and evergreen subject of the training of an engineer. He says, "The future is to the practical man—one who with wide and thorough knowledge of theoretical principles is fully alive to all the actualities of practice." And again "Where it can be arranged the study of theory might proceed side by side with practical training, which is a much better system than that of dividing them into water-tight compartments." He has treated this subject in an extremely able manner, and he has thrown a good deal of fresh light upon this subject, which some of us might have thought was impossible. At the last conference at the Institution of Civil Engineers we heard so much about it that we might have thought nothing more could be said on the subject.

As to specialising, I am quite sure that we ought to be very careful where we draw the line. There could be no greater mistake than for a man to start his training (which, I am sure, you will agree with me, does not merely mean the acquisition of theoretical knowledge) by too early specialising. On the other hand, of course, the time must come when, in the majority of cases, specialising must fall to our lot. But I am more convinced as years go by that the right thing is not to begin with specialising, but to let it fall into its place later on as circumstances develop. Not many years ago one of the Presidents of the Institution of Civil Engineers said, in endorsing and enforcing this point, " I may tell you that of my colleagues on the Council of the Institution at present I believe there is hardly one who is not now following a branch of the profession different from what he embarked upon at the outset of his career ; and I myself am one example." So we must be very careful when we let specialising commence, and we must let it be a superstructure erected upon a very firm foundation of general preparation both theoretical and practical, combined in the way that the President has so well described.

And then I must touch upon the subject of standardising, which is an extremely fascinating idea, though it can easily be carried too far. Indeed it almost seems that we shall standardise everything. I have sometimes thought that it might be an advantage, for the rising generation particularly, if some standardising of text-books could be undertaken, because it is often difficult for a young engineer to determine what his text-books should be. There are several as you know, and they are not all exactly alike.

Then, again, I think that we heard at the Institution some suggestions as to standardising the training of an engineer, and I lifted up my voice against it, and I hope that you will do the same. I believe that if we were to see the training of the engineer standardised it would take away that initiative and individuality which the President has alluded to and which is absolutely essential for the engineer. If we are going to standardise the training of our engineers, it looks as if we were going to try to turn them out all alike ; and I do not think that we can imagine at the present time, or in past times either, a state of the profession in which everybody has been standardised.

We mourn the loss of Sir William White. He was a great example of one who combined in a wonderful degree the science of his profession and the practical application of it. We cannot imagine him doing the great work he did if he had not been a man who had practical experience and a great individuality.

I am sure you will very cordially join with me in thanking the President for this address, which we shall read again with great interest, and I am sure that we shall wish him a successful year of office. It is just twenty years since his father occupied the Presidential Chair, and we had under him a very successful year. We did not then,—and I do not suppose that he did—look forward to the time when his son would be our President. I am certain that it would have been the greatest gratification to him, and we feel sure that his example and his success are going to be repeated again during the present year.

It is very easy for us to stand here and to thank the President, and say, " We are obliged to you for your address," and so on. But I think that we should do something more. We should make up our minds that we are going to back up the President in making this a successful year. We shall be doing it for him, but we shall also be doing it for ourselves, as of course the success of the Society is dear to all of us. He alluded to our endeavour to find work for young engineers when their period of training is over. We have an Employment Bureau which is doing very good work for the members, if they will only take advantage of it.

There has been an interesting departure made already this year with reference to the affiliated Societies. For the first time on record a paper by a member of one of these Societies has been printed as an undiscussed paper in the Transactions of our Society. This should be an encouragement, to the members of the affiliated societies, who, we are glad to see, are joining us in large numbers. I ask you, gentlemen, to join me in a very cordial vote of thanks to our President for his address, to which we have listened with so much interest and which will be such a valuable addition to our year's volume of Transactions.

Mr. H. C. H. Shenton :—It is my pleasing duty as senior Vice-President to second the vote of thanks to the President for his excellent paper. This address is a very important one, and it seems a pity that we cannot discuss it. There are many good points which are of vital interest to all of us. Of course, as the last speaker said, one may make some small reference to the contents, and I think that perhaps the most important point which has been brought forward is the matter of the organisation of the profession. I am speaking without inspiration, so it must not be thought that I am expressing any official opinion of the Society; but I do think that it is to be hoped that this Society should take the lead in trying to effect something in the way of organisation. There is an immense amount to be done. Other professions have managed it, and, if the work is started by this Society, a great result may follow. It affects every one and especially the younger members, because, in the first place, one of the things that can be done is to consider the question of employment. There is at the present time a very great difficulty, perhaps, in finding employment, but there is the vastly greater difficulty of finding the man to fill a position when that position is vacant, and it simply shows that there is a want of organisation altogether. I will not say any more, though I should very much like to discuss this excellent address. I will merely second this vote of thanks and add my best wishes to the President for a successful year.

The motion was put to the meeting by the proposer and carried with great heartiness.

The President :—Mr. Wilson, Mr. Shenton, and gentlemen, I must say that when I started to write this address I had not the slightest idea how long it would take me to do it. I knew what I wanted to say, and thought that it would not take me very long to put it into order. But, as a matter of fact, I was very glad to find that I should have a month longer than I expected in which to prepare it.

Mr. Wilson has referred to the fact that it is just twenty years since my father occupied this chair. That was in 1893 and it may interest you to know that, wondering how long my address should be, I asked my assistant to turn up my father's as a guide, and in looking through it, I found that in beginning my address I had used exactly the same phrase that my father had used 20 years before.

It is usual in delivering a presidential address for a man to devote himself to the particular branch or branches of engineering in which he practices, and it was not without some misgiving that I abandoned that precedent, but I thought that, as this Society was one with members in every branch, I ought to deal with subjects which were of general interest and in which as it happens, I myself have a very particular interest. Mr. Shenton has referred to the fact that he hoped that the Society would take up this kind of work. Well, of course, as he knows, and as members know too, we have already begun to do that kind of work as far as we are able. We find, as everybody else has found, that the old work of reading papers is, I will not say obsolete, but not nearly so necessary as it used to be, because of the magnificent technical press that exists at the present time. The work, however, to which Mr. Shenton refers and which I have touched on in my address to-night, urgently requires to be done much more extensively and effectively than has hitherto been attempted. We have been developing our activities in regard to all matters relating to the organisation of the profession, but what we can do will depend, of course, upon the support we receive. If you are going to do all the work that I suggest here you want an organisation, which should include the greater portion or say half of the whole profession. The

British Medical Association contains I believe about two-thirds of the whole profession. But its prestige is so great that men outside the British Medical Association act in accordance with the decisions of that Association.

Well, gentlemen, I thank you very much for listening to me so long and so patiently to-night and if my address has been of interest to you I am amply repaid for the time and trouble expended on its preparation.

7th April, 1913.

ARTHUR VALON, M.Inst.C.E., PRESIDENT,
IN THE CHAIR.

HOW TO IMPROVE THE STATUS OF ENGINEERS AND ENGINEERING WITH SPECIAL REFERENCE TO CONSULTING ENGINEERS.*

By WILLIAM RANSOM, A.M.Inst.C.E.

THE profession of engineering has the greatest practical bearing upon civilization and the world's progress. Its activities change the face of Nature and its members use her laws for the benefit of mankind. The advantages of modern civilization could not have been secured without the aid of the engineer. As hamlets have developed into villages, villages into towns and towns into cities, so the engineer has been obliged to keep pace with the problems that have marked the progress of the human race. But there is danger that whilst the public have modern advantages, they do not sufficiently appreciate the steps by which these advantages have been gained or the men whose work has secured them. The dignity of the engineering profession has sometimes been lost sight of, and the public require to be reminded that the civilization of to-day has become possible only because of the efforts of the engineer. Members of the professions that have secured for themselves certain privileges are on that account apparently given a more stated place in public esteem, and because the opinion of the people is usually founded upon impressions conveyed by outward appearances, the closed professions are thought to be superior to those that are not so privileged. The existing status of engineers is very far from satisfactory, for the public have not been taught to appreciate the profession of engineering at its proper value. It is very necessary that the public should, without further delay, be made to realize that our profession is one of the most important, and that its members, without being arrogant, endeavour to uphold and enforce the dignity of their vocation.

It cannot be denied that, in the past, engineers have been content to let their work speak for itself, rather than to seek honour for themselves or their profession ; they have been loath to close their ranks, and have been willing to recognize as engineers many who, while possessing certain qualifications, have not attained to a proper professional standard of learning and experience. The consideration that has been shown to such men, who of course have to obtain their livelihood, has tended to lower the dignity of the profession. The time has now come for the status of engineers to be improved, and one of the first and most delicate tasks will be to guard the entrance to the profession. We have many lessons to learn from the legal and medical professions, both of which very carefully exclude unqualified men from their ranks, and exercise a beneficial professional control over their members.

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* This essay gained the second premium in the Status Prize Competition last year, the first premium not being awarded.

No one should be allowed to call himself an engineer until he is suitably qualified. It is as much in the interest of the public that those who plan or control engineering works of all kinds should be properly qualified, as it is that legal and medical men should be trained and equipped for their work. The State should recognize the engineering profession by giving it an official standing equal to that of the legal and medical professions. The reasons why engineers have hesitated to close their profession may be that in past years many of its most prominent members have, to their credit, risen from the ranks, and that in a closed profession there is always the danger of excluding practical men while admitting mere theorists. This danger may have been serious in the past, but nowadays everyone has the opportunity of securing a sound education, and the practical man has an equal chance with others to obtain scientific training. A happy combination of theory with practice is necessary to make a successful engineer, and the time has surely come when admission to the engineering profession should be open only to those who can show that they have taken full advantage of their opportunities for practical and scientific training. This education need not be costly, but it would weed out those who had no aptitude for the profession, and would help to raise the dignity and status of the profession in the eyes of the public.

A State or qualifying examination for engineering aspirants should take in practical as well as scientific knowledge, and in addition a period of special training in workshops or upon large engineering works should be required. It is sometimes difficult for pupils and juniors to obtain facilities for the inspection of large engineering works, although opportunities arise in connection with the visits organized by engineering societies, but it ought to be made possible for recognized pupils to visit from time to time all engineering works undertaken by the State or by municipalities. Practical knowledge would thus be gained and such a course of visits should be compulsory for those desiring State recognition. If the engineering profession is to be protected by State recognition of this kind it is imperative that the qualifications of those enjoying such protection should be beyond reproach. The profession must not shrink from imposing stringent regulations, in order to show the public that engineers are men of high qualifications whose calling should be esteemed as one of worth and dignity.

Entrance into the profession of engineering by means of pupilage is a matter that requires careful consideration. At present all who can afford a premium are admitted as pupils and, as a result the professional world is flooded with junior assistants who, in order to obtain any sort of position, must be willing to accept meagre salaries. The number of pupils allowed to any engineer should be regulated by the extent of his practice. The public will appreciate a profession into which entrance is difficult, and will give more respect to those who, having difficulties to surmount, have been able to qualify themselves for such a profession.

Much has been said for and against the preparation of students and pupils for examinations. No other form of test is possible, although examinations can be made of more permanent value to those who prepare for them. The State or official examination for engineering pupils and students should form the climax to a period of pupilage and should test the store of information that has been acquired upon engineering works, as well as the scientific and theoretical knowledge gained during the period of office training.

There are some, whose experience has been derived chiefly from practical work, who underrate the scientific knowledge that can be acquired by study; while others have little sympathy with the man of practical experience who has not been trained in theory. These divergent views should be brought into harmony and the engineer should recognize that he can be well equipped for his profession only by cultivating both its practical and theoretical sides. These arguments apply equally to the architectural profession which, it is interesting to note, is in advance of the engineering profession, inasmuch as it has applied for and practically received State recognition. It is not exactly a closed profession, but it has made the first step towards that ideal. The engineering profession, if it wish to retain the highest public respect, should endeavour to progress in the same direction. There need be no rivalry between the engineering and architectural professions. The border line should be sufficiently elastic or indefinite to allow the engineer to design his own buildings and the architect to design sewage disposal works for a country mansion. Parliament should give State recognition and protection to all professions, thereby securing to the public the greatest safeguards against incompetence.

If the engineering profession were thus recognized, and the entrance to its ranks regulated and guarded, it would be established upon a firmer and more dignified basis, and the status of engineers would be placed on a level with that of the closed professions. Engineering is second to none of the professions in importance, but because its exponents have been backward in asserting their just claims to public notice the world in general has been inclined to regard the profession as secondary to those that have secured State recognition.

It will become increasingly necessary for the dignity of the profession and in order to deserve the privileges of such recognition that the training of future engineers shall receive careful and thorough attention. At present only a few engineering pupils and students are able to afford the expense of a course at one of the engineering schools or colleges, and therefore an endeavour should be made to provide more facilities for engineering training at the various municipal technical schools and institutes.

The great desire of all engineering aspirants is to gain a wide experience, and at the close of the pupilage period it ought to be made easier for assistants to gain experience in other offices and works. It might be possible, if greater professional *esprit de corps* were cultivated amongst engineers, to arrange a system of exchange, by which pupils might obtain experience of many kinds of work, besides gaining a broadened outlook through being brought into contact with other professional minds. At present, experience is obtained in a spasmodic and haphazard way, while but few have opportunities of seeing works in course of construction, except at a great financial sacrifice. Military engineers make special visits to works up and down the country in charge of a competent professor or engineer, and as already stated, it would be an advantage if pupils and assistants of civil engineers could, without great cost, gain practical experience in this way. The young engineer often cannot get this experience until late in life, when further professional advancement is a matter of comparative indifference to him. The visits organized by engineering societies are not always available to juniors and assistants, who stand to profit most by them.

When State recognition is obtained for the engineering profession it would follow that all the members of the profession would constitute one great society. At present there are several engineering societies that might with great advantage be amalgamated into one statutory body, which should have the professional control of its members. Many engineers find that subscribing to a number of societies is a heavy financial burden, and it would be more satisfactory from a public point of view to have one great society, whose authority would be recognized not only by its members but by the State and the public. This organization would be the mouthpiece of the profession, and would regulate professional etiquette and conduct, while its decisions would serve to uphold the proper status of the profession.

One must, however, admit that the practice of engineering embraces so many subjects that, in the one large society, it would be expedient to have sub-sections dealing with special branches of the profession. The tendency to-day is for a man to specialize in one subject, and to become, if possible, a consulting engineer in one special branch of the profession. He endeavours to gain experience that will equip him for consultative work, because it places him upon the highest pinnacle of the profession where the emoluments are correspondingly high. If the societies now in existence were amalgamated, and sub-sections formed to further the interests of specialized branches, the profession would present a united front.

While the growth of specialization must be recognized, it would be well at the outset to enforce a general knowledge of all branches upon those who wish to enter the profession, so that a pupil would find it necessary to acquire a sound general scientific knowledge before he began to specialize. The specialist cannot be made in a day, and the consulting engineer, to be of value to the community, must earn his title to that rank by long experience and assiduous study of practice and theory, and step by step advance up the professional ladder to the pinnacle of fame.

Engineers can learn much from the societies that control the legal and medical professions and uphold a strong code of professional conduct and etiquette. The engineer should not be one whit behind his brethren of other learned professions, while the society that represents him should maintain a high standard of professional honour and must have power to enforce its regulations. The *esprit de corps* that is shown by members of the closed professions should be even more manifest among engineers, and professional rivalry should not be so keen as to allow of the acceptance of inadequate fees in order to divert work from one channel to another. Minimum professional fees should be fixed by the State, as in the case of the legal profession, and touting for engagements, or the acceptance of fees below the legal standard should be regarded as unprofessional and undignified. The dignity of the profession has often been dragged in the mire because some of its members have treated matters from a purely business point of view, and have lowered their standards for the hope of mere monetary reward.

All have to live, and fees are but the honourable reward of labour; and the profession should make sure not only that adequate remuneration is provided but that the best possible professional service is rendered for the fees received. Engineers who have their hearts in the work will always be worth their fees, and the more dignity that is given to the profession the more willingly will the public pay their remuneration.

The consulting engineer plays a great part in forming public opinion on the profession, because he has qualified by long and special experience for work that requires wide knowledge, and from the very nature of things there can be but few men who are able to qualify as consultants. They are specialists, and the public places a high value on their services because they are comparatively few. Consulting engineers have therefore given tone and dignity to the profession and the latter would gain if it sought to bestow upon consulting engineers of note some academic distinction that the public could recognise as a hall mark of eminence.

In large engineering works consulting engineers find it necessary to employ resident engineers to guard their interests, and to represent them at all stages of the works. Contractors are naturally anxious to make as large profits as possible, and while it is not necessary to imagine that they are rogues and always ready for deception, there are so many opportunities for unscrupulous men to take advantage or for unworthy workmen to shirk their work that consulting engineers, for their own protection, should have representatives upon the works to report progress and to check the work from day to day.

Resident engineers have very responsible posts, for the success of the works in many cases may depend upon the care with which they interpret and cause to be carried out the designs of the engineer-in-chief. The resident engineer should be, in the absence of the consulting engineer, the man in authority upon the works in regard to engineering problems. He should be the mouthpiece of the consulting engineer, and nothing should be done to lessen his authority with the contractors. Unfortunately, where the resident engineer is a weak man and has not the entire confidence of his chief, the contractor all too quickly sees the nature of their relationship, and appealing direct to the consulting engineer, undermines the authority of the resident engineer and causes unpleasantness and friction throughout the work. Consulting engineers are not altogether blameless in this matter, for sometimes when they have placed resident engineers in positions of responsibility, they approach the contractors direct and apparently ignore their own resident engineers, instead of issuing instructions and orders through them. The proper professional and dignified course to pursue is to pass all communications to the contractors from the consulting engineers through the resident engineer.

It would be well if a code of professional conduct were drawn up, to which all who sought admission to the profession would have to subscribe, and consulting engineers would further the highest interests of their profession and more firmly establish its status if they agreed without further delay to adopt a code of professional conduct and etiquette. It is because the legal and medical professions have and observe such a code that they are held in such high respect by the general public.

Consulting engineers must be upon their guard against unscrupulous contractors who are not averse to placing temptations before resident engineers. To such unscrupulous men the dignity of the profession stands for nothing, as they act upon the principle that all men have their price. The opportunities for fraud between an unscrupulous contractor and a complacent and negligent resident engineer are very serious. Such contractors are, however, soon checked when brought into contact with men of strict integrity. It may be remarked incidently that a liberal scale of remuneration would place engineering assistants and resident engineers above possible temptation. The salary of a resident engineer is often meagre and is very grudgingly given by many local authorities ; but if the public fully understood the responsibility of resident engineers and how much depends upon their integrity, their salaries would be willingly given on a more liberal scale. Consulting engineers could do much to create a healthier public feeling in this matter by impressing upon their clients the importance of these posts and the value of the services that are rendered.

Doubtless some men are anxious to keep their juniors in the background lest they should receive praise that might otherwise be given to their chief, but the engineer who has the true professional spirit will always admit the merit of his juniors, remembering the time when he too was young, and when a word of praise did more to raise his ambitions than any success in after life.

Consulting engineers who have risen to the top of the profession can afford to be generous to those who are yet at its foot, and while maintaining the dignity of their position can help to establish their status more firmly by giving a helping hand to uplift their struggling juniors. The relationship of the consulting engineer to his assistants and pupils will have a lasting effect upon the future professional life of the latter His personality will make its impress upon them, and shape their future professional conduct. The tone of an office depends very largely upon the amount of personal interest that the engineer devotes to his pupils and assistants. Many valued and lifelong friendships have been formed in the office, and these relationships have always had the most beneficial effect where the engineer-in-chief has been respected as a friend, counsellor and adviser rather than as a master and employer. When it is remembered that the professional men of the future are at present in the offices and under the personal control of engineers who are now at the head of the profession, it is possible to realize that the future can be moulded and controlled to whatever ideal consulting engineers may like to place before themselves. The future status of the profession is in their keeping. Where the chief sets before himself a high standard of professional conduct, his pupils and assistants will insensibly be affected by his example. They will endeavour to uphold the dignity of the office and of the chief with whom they are associated, and they will start their professional life to all intents and purposes pledged to pursue a conscientious course of action and to adopt the very highest code of honour. Consulting engineers of such a moral calibre are rendering the very highest service to their profession, and doing almost all that is possible to maintain its status in the professional world.

Engineers should feel it their duty to follow with interest the future careers of those who have entered the profession under their care. The more that is done to promote a keen professional and fraternal spirit amongst members of the profession the higher will be the esteem with which it will be regarded by the general public. Nothing will more readily promote distrust and disgust than the exhibition of contemptible feeling or the display of petty rivalry or jealousy amongst professional brethren. Those professions that are most bound together by mutual ties of regard and protection are the most respected by the public. When it is realized that an aspersion upon any-one member will be resented by the whole body the public will understand that the profession is one to be treated with respect.

The manner in which the profession appears before the public is one of considerable importance, for the public is apt to judge by external appearances, and to form their opinions, rightly or wrongly, upon impressions gathered from the general standing of the profession. If they should find that its members are lacking in dignity, professional honour or mutual respect, the public will quickly take the cue, and in return treat the profession with little respect or with indifference.

The tone of the profession cannot be given simply by the various professional societies. They may and should present ideals and endeavour to educate their members to a high code of honour. Each individual must live up to a standard, and the public standard for the profession is that which is presented not by the best members but by the average members. How important, therefore, is it for each engineer to set an example of lofty ideals before his own staff, his clients, and the public. The status of the profession must be maintained not by mere legislation, for that is impossible, but by individual effort, and the consulting engineers who figure most largely in the public eye can help to establish that high code of professional honour that alone will improve the permanent status of the profession. At the same time the professional societies play an important part in forming public opinion, which is largely influenced by what is recorded in the press. The value of conferences and meetings for the exchange of professional opinions and experiences cannot be too highly extolled; and where these are developed upon the right lines, allowing special facilities for the junior members, who, after all, are most in need of experience, the public will not be slow to realize their usefulness, and will be impressed by the efforts that are made by the profession to equip its members for the fulfilment of their varied duties.

The chief aim of the profession to-day should be to improve the facilities for the education of its future members. Only thus can the status of the profession be permanently raised, and engineers take their proper place in the estimation of the public. The day schools should be allowed to form a sound elementary foundation upon which a professional career can be steadily and securely erected by a combined use of the office, the workshop and the technical institute. There are very few who can afford a collegiate or university training, but it ought to be possible so to re-organize existing agencies as to enable any engineering aspirant to equip himself fully for a professional career, and to attain a degree of success limited only by his own ability, industry and integrity.

The engineering profession is one of the noblest in the world. It is creative, and is controlled by the laws of nature. It has been well said that he is a public benefactor who enables two blades of grass to grow where formerly grew but one. What then shall it be said of the engineer who makes it possible to enlist in the service of man all the great forces of Nature? He is performing the highest of services, and makes it possible for mankind to progress from triumph to triumph. The dignity of the profession consists in the work that it performs, the labour that it saves the community, and the advantages and luxuries that it brings within the grasp of mankind. The highest honour that can be done to the engineer is to recognize that he is engaged in the service of mankind and that his work in all ages is a lasting memorial to the genius of his profession.

Discussion.

The **President** moved a vote of thanks to Mr. Ransom for his paper. The subject was, he said, one of very great importance, and people were beginning to talk about it. He had himself read two papers on it, and he had seen others referred to within the last two or three weeks. It seemed that engineers were awaking to the fact that something must be done. A gentleman to whom he was speaking on the subject recently said, "It is all very well to talk, but what are you going to do?" There was a great deal of force in that question, but still they must discuss the matter and determine what ought to be done. The question of status was a very complicated one in many ways. The status of the profession and the status of individual engineers were two quite different things, and yet they acted and re-acted on one another very materially. The status of a class in the eyes of a community depended partly on the social status of the members who formed it, and the social status of the class from which it was recruited. That fact had to be remembered when they contrasted engineering with the closed professions. Until fairly recently the closed professions had been recruited from what might be called the upper middle class, although now they were beginning to draw their recruits from a much wider area. The engineer's profession included men from every class of society, and there was that difference between the engineering profession and the closed professions. That was a point that affected the problem. If they attempted to apply compulsory registration to engineering they would meet with many more difficulties than were met with in the medical or the legal profession. Engineering was so wide that it was extremely difficult to know what qualifications should be imposed for registration; and that, he thought, was the first of the great difficulties that lay in the way and would have to be overcome.

It seemed to him, as he had said on a former occasion, that all the ills which were mentioned in the paper and many others could be dealt with in one way quite effectually, and not in any other, and not even by registration. That way was organisation. If they wanted things altered, they must organise the profession as a whole. It was not of the slightest use for just a few people or a comparatively small society to lay down rules or attempt to bring about alterations. There must be practical unanimity in, at all events, an influential body of men who were willing to give time to the necessary work. Organisation was to be found even in the case of the closed professions, and it was found to be required in addition to registration. The British Medical Association depended partly on the power of organisation, and not entirely upon registration. Registration, if they could get it, would be a good thing ; but, personally, he believed that there was need for a real organisation that was strong enough to make its own will felt, and to make its own views the views of the profession generally. It must be able to make rules and see to that they were obeyed. He did not think that anything would be of much use unless the members of the engineering profession were ready to make the sacrifices necessary to form and to work an organisation.

Mr. Henry C. Adams said that he took "status" to mean generally the regard in which the individual engineer and the profession were held by the public. Engineers might be divided roughly into two classes—assistants and principals. As regards assistants, the question of status did not crop up very forcibly, because the principal took all the credit, and, incidentally, the greater part of the money, although the assistant might do the greater part of the work. As a matter of fact, however, the estimation in which the profession was held by the public depended to a certain extent upon the assistant. But how could assistants maintain the status of the profession on the miserable salaries that they received ? There was no doubt that engineers would willingly pay higher salaries if they could get assistants upon whom they could rely to do the work in the way that they wanted it done. There was a general complaint that they could not find assistants of that kind. There were many highly qualified men with whom it would be a pleasure and an advantage to work, but there was a difficulty in finding them. On a previous occasion he suggested that, in order to counteract this evil, engineers should form a central bureau. He thought that every engineering student, when he commenced his studies, should have his name entered, and all that he did from time to time should be vouched for and recorded in the register. Then, when he was applying for a situation, he should be able to get a certified copy of the entries from the register, and no applications but those of men thus certified should be considered. The prospective employer would then know perfectly well what he was getting, and he would probably pick out a suitable man. At present the employer was working in the dark, and he frequently did not get the best man from among the applicants.

As to the consulting engineer, or the man who was in practice on his own account, it seemed to him that the regard in which such a man was held was in direct proportion to his income. When a man was at the top of the tree and was making ten or twenty thousand a year, everything that he did was perfectly right. What they needed to do now was to educate the public. He did not see that any advance would be made by those men about whose status and qualifications there was no question at all collecting together and putting forward rules of conduct. Every respectable engineer invariably bound himself to such rules without giving any specific undertaking to do so. What they wanted was to go to the outer ring and rule out or get rid of those persons who had no right to call themselves engineers at all. Any ordinary member of the public could always say what the duties of a contractor were, but the public knew nothing at all about the duties of an engineer. Everybody in the neighbourhood of large works could tell the name of the contractor, but nobody knew the name of the engineer. The public needed to be educated up to appreciate the position and the importance of the engineer.

As to fees, it could not be too widely known that the universal fee of 5 per cent. was charged by the most eminent engineers and also by the least qualified man who accepted work ; and the saving in the cost of a scheme as the result of employing a qualified man instead of an unqualified one would probably be sufficient to pay the whole of the engineering fees.

He was quite sure that no qualified engineer objected to its being known as widely as possible that if a man undertook engineering work he was liable to pay the cost of rectifying all mistakes which he might make in consequence of any lack of reasonable engineering skill. He would say nothing for the moment as to how low the qualification should be put, but if totally untrained and uneducated men were prevented from calling themselves engineers, the status of the profession would rise at once without any direct effort being made.

As to the number of pupils taken by an engineer, he was strongly of opinion that it should be limited, but he did not think it feasible to regulate it in strict proportion to the extent of the engineer's practice, more especially in the case of the engineers of large works. The objection to the number being governed in that way was that in such case there would or might be a large number of pupils, and the employer could not give to each pupil that proper personal supervision upon which the pupil's efficient training and subsequent welfare was so largely dependent.

He thought that Mr. Ransom was in error in stating that the architectural profession had practically received State recognition. He believed that the architects had got as far as preparing a draft Bill, but it was certainly not a Government Bill, and he had not heard that it was supported by any member of the Government, neither did he think that it was likely at present to get any further than the draft.

Then Mr. Ransom seemed to desire to cheapen education for engineers and provide more facilities at the various municipal technical schools. To cheapen education was all right, but they must be thorough, and they did not want to turn out a lot of half-qualified engineers from the technical schools.

It was not clear to him why the *esprit de corps* shown by the members of the closed professions should be *even* more manifest among engineers. It would be interesting if Mr. Ransom would elaborate that point.

He might also, when replying, be a little more explicit with regard to what he meant by his objection to engineers considering matters from a purely business point of view. Unless an engineer had considerable commercial aptitude, he would, sooner or later, no matter how learned he might be, erect a monument to his own ineptitude and lack of sense of proportion.

However much engineers might differ as to the best means to adopt to improve their status they would, he thought, all combine in agreeing with the author that the engineering profession was one of the noblest in the world.

Mr. W. A. Tookey said that they had heard from three different speakers that what engineers had to do was to educate in some way some great body called "the public." Which particular section of the public had they to educate? The engineer did not have to cater for the general body of mankind as medical and legal practitioners had to do. Everybody at some time during his life had to consult some man learned in medicine or in law, but, unfortunately, engineers very rarely had opportunities of giving their professional services to individual members of the community. Their clients mere mainly municipal or commercial groups of individuals. Civil engineers dealt with local bodies, mechanical engineers dealt with manufacturers, and so on. He thought that the engineering profession as a body must make up its mind which were the particular sections of the public whose goodwill they would cultivate in the interests of the many branches of engineering science, and must take the necessary steps to emphasise the importance of obtaining skilled advice even in the details of minor engineering projects.

Without a shadow of a doubt many manufacturing concerns to-day were simply wasting money upon their plant for lack of a competent engineer. In the case of a good many factories the man whom they called their "engineer" was found to be a mechanic. He was probably of the status of foreman mechanic, but he was certainly not an engineer in the proper sense of the term. There could not be any doubt at all that if manufacturers were made to realise the financial advantage that they would reap from the employment of a skilled engineer to superintend all manufacturing and other details, who would be able to keep them out of all their present difficulties and to run their machines at the lowest possible expense, all things considered, they would not be at all loath to employ a professional man. Manufacturers were certainly one class of the public whom engineers had to educate, and if each factory had its own engineer—a man of professional status—the profession as a whole would benefit in the same way as the general body of medical practitioners benefited consultants, solicitors benefited barristers, builders benefited architects, and so on. Many engineers had already, in a way, registered and classified themselves by becoming members of the various engineering bodies throughout the kingdom. Therefore, he thought that registration and classification was not the most pressing necessity, but there was every necessity for openings to be made for the junior men when they had gone through their apprenticeship or pupilage, in order that, at the end of their training and at the beginning of their real career, they should have a chance of obtaining posts at which they, at any rate, earned a living wage. But with regard to classification, he thought there was at the present time no system by means of which the public, speaking in a general sense, could obtain information as to the names and qualifications of engineers who were specialists in any particular branch. That seemed to him to be another want that ought to be met. Steps should be taken by each engineering society to publish for the public inspection a list of its members, distinguishing between the different grades and between those who were available for consulting work, those who were civil, mechanical, electrical, automobile, marine, or mining specialists, and so on, right down the scale. It was owing to the lack of any register or any directory that was easily available to those who wanted to employ men that engineers frequently did not hear about some matter in which their services could have been rendered before that work was snatched up by somebody on the spot who was not as competent but was more accessible. It was for the lack of such a directory that the competition of insurance companies and paid officials of manufacturing and other concerns with professional men was at present so keen, and so detrimental to engineering and to the community.

Mr. Reginald Ryves said that by far the most important of the points which had been mentioned was the point that, in order to succeed in the attempt to better the position of engineers it was necessary to organise; but it was essential to carry the word "organise" a little further and to explain exactly what was meant by it, and to say quite definitely that by "organise" they meant "fight." The chief reason why the position of engineers was unsatisfactory at the present time was that they did not assert themselves and did not fight. It was the fact that any man of ordinary abilities who held a good position held it through organisation on the part of his ancestors or of his predecessors in title or of some other body of men. What was the difference between what the doctors were getting under the Insurance Act and what they would have got if they had not absolutely fought? He believed that the difference was something like 50 per cent. The same sort of thing was found everywhere. Organisation for fighting purposes was essential for protection, but sometimes it was necessary to carry the war a little way into the enemy's country in order to make the protective measures effective. It ought to be clearly understood that, if the profession of electrical engineering or mechanical engineering was attacked, the whole profession of engineering would rise in defence of the branch. It ought to be understood that anybody who attacked the profession did so at his peril.

There were two ways in which the necessary combination could be brought about. One was by every person who joined the engineering profession as a student becoming at an early stage a member of a general society composed of members of all the branches of the profession. The other way was by the formation of a committee, backed up by all the societies, and on which all the societies were represented. He thought that, on the whole, the latter would be the better plan. Until some such committee was formed the matter of organisation could not be upon a satisfactory footing. He was looking forward to the time when such a committee as he had indicated would take matters out of the hands of individual societies and would become a body with considerable life of its own. He could not see why such a committee should not be formed as a permanent body to advance the interests of the profession. Engineers acted in concert for the advantage of the public; then why not for their own advantage? There were Engineering Standards Committees upon which different branches of engineering were represented as well as, in some cases, other interests. He did not think that there was any need for any one society to wait until others were ready. Why should not any society which agreed with the principle adopt it, and say, "We henceforth shall be known as a society willing to form part of the Committee and to appoint a member of it"?

One point of great difficulty was due to the fact that, though engineers used the word "engineer" to describe themselves, it was not English for what they meant. In the ordinary way the word "engineer" meant anything, beginning with the fitter's mate. He did not quite see how the difficulty was to be got over unless engineers gave up the word "engineer" and adopted some other word. Until there was some registration of engineers it would not be possible to prevent men from using the word "engineer" as they pleased, and the word would be used to describe any person who was a mechanic in any shape or form.

A question had arisen with reference to the public knowing what an engineer was. It seemed to him that that question was linked with the question whether engineers were to qualify only as specialists or as general practitioners also. He thought, with all due respect to the very highly qualified specialists, that the consulting engineer as a general practitioner was somewhat underrated. The consulting engineer did not pretend to understand all that there was to know about one thing or a group of things. The term "consulting engineer" represented an attitude of mind. A consulting engineer was a man who approached his problems with a special attitude of mind which in some respects and up to a certain point was very much the attitude of a barrister dealing with a brief. He went into a matter thoroughly and with a greater amount of energy than the executive engineer or the person promoting the work, because he was only going to be engaged upon it for a short time. It seemed to him that one of the points to be discussed was whether it was not better to encourage the general practitioner or consultant a little more. He did not mean that any kind of engineer should pretend to be a general practitioner in the sense in which a medical man was. He might have three or four subjects, but he could not, of course, cover the whole range. The reason why the public knew nothing about the engineer was that the engineer was a mysterious person who came up from Westminster and who walked about the works for a time and then went away, leaving several young fellows behind him who were supposed to have something to do with the engineer. The consulting engineer was not interested in the locality, and he was not known. He thought that engineers were a little too heavy on the specialist in their relations with the public. Although the specialist was very valuable, engineers ought not to rely upon him only for keeping up their reputation with the public.

In speaking of engineers the author spoke of the practical man and the theoretical man. He (the speaker) had always had a difficulty in distinguishing between the theoretical man and the practical man. In fact, he did not pretend to so do. It must be admitted that, if there was a practical way of approaching a subject and a theoretical way, there was also a third way. "Practical and theoretical" did not cover the whole ground. It was necessary to reckon with deduction, or to use deduction as a kind of solvent. If one did not admit the possibility of knowing how to do a thing by deductive reasoning, he cut out a good deal of very useful consulting work such as is based neither upon theory nor upon actual experience.

Mr. Paul Mallmann said that the speaker who opened the discussion had divided engineers into two classes, principals and assistants. After twenty-two years' practice in this country, Germany, and the States, he divided engineers into those who knew something and those who knew nothing. He was sorry to say that very many in this country belonged to the latter class. He thought that if there was applied a principle adopted in Germany, France, Austria, and in many of the States, of a State examination, and only those who were qualified were allowed to call themselves consulting engineers, the status of the engineer would immediately be improved.

Fighting had been mentioned. Let engineers fight by all means, but if they wished to fight they must have a fund. Engineers wished to be recognized by Act of Parliament in the same way as parsons, physicians and lawyers were recognized to belong to learned professions. The passing of a Bill for the purpose would involve a considerable amount of money. The question of who was to find the money would have to be considered before the first steps were taken. If engineers did not know where the money was coming from, what was the use of spending time and looking learned and considering and meeting and talking ? Why, then, not simply go to the State, and say, " Please do the same as has been done in Germany, France, Spain, Austria and other countries. Define clearly and distinctly certain examinations to be passed in order to qualify a young man to apply for an examination under the auspices of the State " ? The question would then be raised, " What is going to happen to those who have for years practised successfully as consulting engineers ? Are they to go again to school and pass examinations ? " This would not be necessary. Those who were members of the acknowledged institutes, namely, the Institutions of Civil, Mining, Mechanical and Electrical Engineers would be admitted to the status immediately, but the younger men would be submitted to a systematic and thorough State examination.

Germany, Austria, Russia, France and Spain all made it a condition that any young man applying to a particular University to pass the State examinations or to study there to qualify must show a record of three years' practical work before State certificates were granted.

Mr. A. H. Dykes said that the root difficulty which underlay the whole question was the meaning of the word " engineer." In this country the word included both the consulting engineer and the mechanic, and every grade between the two. They could not go very far until they had sectionalised a little bit. They could have municipal and county engineers, consulting engineers, marine engineers, and so on, and they would have to work along those lines and let all those sections draw together and combine for their own protection and interest. He should presume that, when the engineering profession was spoken of in the paper, what was meant was the man who had had a thorough engineering training, for be believed that the definition of a profession was an employment requiring a learned education.

One difficulty that he noticed in the paper was the suggestion that " an endeavour should be made to provide more facilities for engineering training at the various municipal technical schools and institutes " ; and then it was said somewhere else that it was not possible for all the men who were to be called engineers to go in for long and elaborate training. The reason that the medical profession held a high position in the eyes of the public was simply that the members had to go through a long and expensive training, and unless an engineer went through a training in some way comparable, he could not expect to hold the same high status in the public regard. One encouraging fact was the steps which were about being taken by the leading engineering institutions to hold examinations. He believed that these were the lines along which progress would be made. The Institution of Civil Engineers now required Associates and Members to pass an examination before being admitted, and the Institution of Electrical Engineers and the Institution of Mechanical Engineers were now introducing examinations for membership. He hoped that all such examinations would be thoroughly practical and not merely theoretical ones, and would thus be a guarantee to the public that the men who passed them and became members of the Institutions were men of education, both general and technical.

It had been suggested that consulting engineers should draw up a code of professional conduct, and that those persons who wished to become consulting engineers should subscribe to it. A great effort had been made during the last three or four years to bring this about. There was already in existence an Association of Consulting Engineers comprising some eighty persons, the majority of whom were well known to the public. They had drawn up a list of rules with which all members must comply, and they were doing their best to educate the public as to the duties and responsibilities of consulting engineers. One difficulty lay in the fact that the average man seldom had to engage the services of an engineer, or he did so only at long intervals, and therefore he had not the opportunity of becoming acquainted with the profession of a consulting engineer and of knowing exactly what he ought to expect. It was hoped that all qualified consulting engineers would join the Association. The committee of the Association had considered very carefully indeed how they could insure that their members were all well trained men, and one step which occurred to them was that every member should be a member of one or other of the three leading engineering institutions that insisted on examinations, and that all their members should be thoroughly well trained. He believed that if engineers went along such lines they would raise the status of their profession in the eyes of the public. It would be a slow business, but it must be remembered that the legal and medical professions were very much older than the engineering profession, and that surgeons at first did not hold the same position that they held now. Surgeons were at first barber-surgeons, and the attainment of the present status of the surgeon had been a matter of gradual progress. Engineers had not started very long, but he hoped that it would not be long before they caught up with the older learned professions.

Mr. W. Kaye Parry wished to say a word on behalf of the Irish engineers. He was quite sure that all responsible members of his profession in Ireland would be in sympathy with what had fallen from the various speakers and realize the necessity for organization and for taking steps for the protection of the profession. Engineers in Ireland had some advantages and a great many difficulties. One of their advantages was that they had a very useful and excellent School of Engineering in Dublin, and in other colleges in Ireland there were facilities for engineering training, so that there was really no excuse for the untrained man in Ireland. At the same time Irish engineers suffered very greatly indeed from the fact that the profession was not recognized, and that any man in the country might call himself an engineer. There was a very large number of men practising who should not be allowed to practise. One thing that could be done and which was suggested to him by a prominent official of the Local Government Board some years previously was that, so far as municipal work was concerned—work over which the Local Government Board had control—it should be made a condition that they would not accept nor pass plans or specifications for any public works unless they had been prepared by a qualified member of the profession, and that they should lay down certain rules and regulations as to what would constitute in their opinion a qualified member of the profession, and that they should refuse to accept, for municipal purposes and for public loans, works which did not come from trained men. Quite apart from the interests of engineers, there were the interests of the public to be safeguarded, and it was absolutely necessary in the interests of the public that engineers who spent their time in spending other people's money, and spending it sometimes in very large sums, should be not only men of training and men of education, but men of integrity and men who could be trusted. From the public point of view it was essential that engineers who were called upon to preside over large works, in respect of the payment for which they had to grant their certificates, should be so qualified that they should be trusted, and that when they signed their certificates there was a guarantee that the work had been honestly done and that the certificate had been honestly given. He sincerely hoped that the outcome of the meeting would be to encourage all the various engineering societies to organize for the purpose of establishing the profession upon a firm basis, both for the sake of engineers and for the sake of the public whom they served.

Mr. John Hewett said that he certainly felt that the thanks of the whole profession were due to the author for having brought the subject forward in so clear and concise a manner. He should like any remarks which he made to be confined entirely to his his own branch of the profession, namely, that of the consulting engineer, as distinct from any other kind of engineer at all. The profession certainly was not in a healthy state. Engineers must take example from professions older than their own, and form what was practically a trade union. The lawyers, the doctors, and the dentists had all formed their own trade unions.

The next thing that was necessary was that some attempt should be made to relegate consulting work to consultants proper, and not to allow, if it was possible to prevent it, any particular individual to be a consultant on one day and a contractor the next day, or perhaps both at the same time. It had been his experience to meet, on one job, as a consultant, a man who had been working under him as a contractor on another job. Another point. The question of fees was always one which interested engineers most intimately. To give some idea of what a consultant in active practice had to submit to, he would refer to his recent experience with a Board of Guardians who contemplated lighting their workhouse infirmary by electricity, and invited him to state a fee for the preparation of the specification and the superintendence of the work. In reply he quoted his usual scale. In due course the Clerk to the Guardians wrote thanking him for his letter, and stated that the offer of an engineer to an electric light and power company to draw up a specification of and superintend the work in connection with the electric lighting of the workhouse infirmary had been accepted. That engineer was the beggar that he should like to hang ; a man who had so many hundreds of pounds a year salary, and was attempting to cut the throats of other engineers ; for no doubt the letter from the Guardians asking for the statement of a fee went to many engineers besides himself. With reference to the moral aspect of it, one of the most important things in the case he had mentioned was the amount of money that the Guardians, and incidentally the ratepayers, would have to pay for their current consumption. The arrangement of the circuits, the type of lamps, the motor work, and various other details could be dealt with in such ways as to cut down the cost of the current to the minimum. Was the man whose reputation depended upon how much money he could get for current the man to advise ? His interests were all the other way.

Mr. A. S. E. Ackermann said that for many years he had taken a great interest in this subject, and that it was a great pleasure to see there was so much more interest taken in it now than there used to be ; *e.g.*, it would have been impossible twenty years ago to get together such a meeting as the present one.

That the status of engineers was not what it should be was, he maintained, entirely their own fault. They needed to be much more public spirited and must be prepared to do a large amount of hard and unpaid work.

Lawyers and the doctors had not had their status made for them. They had made it for themselves as the result of years of hard work, nor had they relaxed their energies. Their enviable position was due to their organisation, and, as the President had said, engineers must organize. When one compared engineering with law or medicine people said that those professions were different. Of course, they were different, but both law and medicine had had great difficulties to overcome, *e.g.*, originally there were barber-surgeons, and it was hardly possible to imagine a more troublesome thing for them to have had to do than to split that calling into surgeons and barbers, though that had certainly been done effectively, for the two callings were now as far apart as one could imagine.

One of the reasons why engineers had not made much progress with their status was that they had no cohesion among themselves, and the reason for this was probably because they were drawn from so many different classes of society. On the other hand, barristers were not drawn from such a variety of classes. In the case of medical men there was still a great difference between the ranks from which they were drawn, but, thanks to the advantages of their organization, the men who came from the lower middle class of society were educated up to a certain standing of honour and etiquette. They had to brush themselves up, so to speak, in order to get into line with the rest of their professional brothers, or the process of getting into their profession brushed them up.

It was significant that many barristers never practised. They read for the law simply for the sake of the standing that the title gave them. Until engineers were similarly organized the public would not think much of them. It was of no use trying to educate the public. Engineers needed to educate themselves first. They did not even know how to treat one another, and therefore they were not likely to get the public to treat them properly.

They needed to have more of the public school spirit. If there were more public school men amongst engineers there would not be so much cause for complaint.

Take the question of fees. How much nicer it was for the professional man and the client for the latter not to have to deal with the principal, as was the case with barristers, whose fees were arranged by their clerks. This method of dealing with fees was one of those hundred and one little things which went to make up the better status of the legal profession.

Then again, take the case of the British Medical Association. That Association did not comprise the whole of the medical profession, for only about 20,000 out of 30,000 registered medical practitioners belonged to it, and its position was strong, quite independently of the fact that the members of the medical profession were registered. Their position was, in fact, so strong that it was not uncommon for a couple of non-members of the Association to ask its ethical committee to settle some difference between them.

The British Medical Association also did most admirable work in keeping up salaries by means of notices in their powerful organ, the *British Medical Journal*. If the conditions of service attached to any medical appointment were unsatisfactory a notice appeared in the *Journal* and that was enough to stop both members and non-members from applying for the post.

The title " physician " could not be used by any man who was not a fellow, a member or a licentiate of the Royal College of Physicians. Dentists also were registered, and, although a large number of unregistered men practised dentistry, they must not use the word " dentist " in describing themselves. They could call their establishments Dental Parlours, and get round the title in such ways, but they could not use the words " Dentist " or " Surgeon-Dentist." Even veterinary surgeons were registered, but engineers were not.

People were sometimes inclined to laugh at the strict etiquette of law and medicine, but did that etiquette in the very least reduce the amount of work to be done by those professions ? It did not. It simply confined it to properly qualified men. These fine points of etiquette might appear absurd in one sense, but the positions of the other professions, and all that was admired about them, were built up on little points like that.

REPLY.

Mr. William Ransom, in replying to the discussion, thanked the speakers who had taken part in the meeting for the help that they had given. It had been said with regard to the closed professions of law and medicine that the members of those professions were drawn from a slightly higher social class than those persons who made up the engineering profession ; but was not that an effect of those professions being closed ? One speaker had said that physicians in the past were of a very much lower social standing than physicians of the present day. The medical profession had been closed and the status of medical men had been improved. So he thought it would be with engineers. Their status would be improved if the engineering profession became a closed one. It would then be on an equal basis with the medical and other professions.

Mr. Adams had asked why he thought that there should be more *esprit de corps* among engineers than among the members of other professions. The progress of engineering, to his mind, depended very largely upon the exchange of experience between one engineer and another. All engineers had failures at times to record, and if engineering was to make good progress it was necessary to exchange experiences of failures between brother professionals, so as to enable the profession to advance to its best.

The question asked with regard to the purely " business point of view " had been answered already by one or two other speakers by the reference made to those professional men who were willing to undercut their brethren by asking lower fees. There were men who were willing to undercut. If there were a proper *esprit de corps* there would not be this mere business rivalry, and engineers would stand upon their dignity and would adhere to a reasonable minimum scale of charges.

One of the great points to which reference had been made was the use of the term " engineer " by a mechanic. He thought that there would be a great advance if registration were adopted, and the term " engineer " were restricted to the profession and the term " mechanic " used by those who were now known as mechanics or working engineers and who could not be included in the profession. As things were now the public were not capable of distinguishing between the two terms, and confused the professional with the manual side of the mechanical world.

A great deal had been said in the discussion about organization. He thought that they all felt that organization was necessary, and they were all talking about it ; but why could not something be done ? He thought that one of the best practical suggestions that had been made in the discussion was that a conference of representatives of the various engineering societies should be held to ascertain whether it would not be possible to arrange a line of professional conduct and endeavour to obtain

State recognition for engineers. This would place the status of engineers upon a more permanent basis.

In conclusion, he thanked the President and the meeting for the very kindly way in which they had received his paper.

May 5th, 1913.

ARTHUR VALON, M.INST.C.E., PRESIDENT,
IN THE CHAIR.

TIDAL WATERS AS A SOURCE OF POWER.

By C. A. BATTISCOMBE.

[MEMBER.]

SOME time ago the author, having a considerable amount of leisure time, studied the commercial possibilities of hydro-electric installations in England and Wales, and was led to the conclusion that, owing to the situation of so many important manufacturing centres near the seaboard, it would be interesting and possibly instructive to discover whether the tides could not be utilized as an indirect means of generating electricity.

He approached the subject with an open mind, and after experimenting with a rough model to verify his conclusions, he selected two or three sites of which he obtained charts and maps with a view to formulating schemes and obtaining estimates based on actual rather than hypothetical data. The results of these estimates were so satisfactory that he visited the Patent Office to find out whether his conclusions were original or had been anticipated. He found that amongst a considerable number of other patents three had been granted for inventions which covered the principles on which his designs and estimates had been based.

There is little doubt that many attempts have been made to utilize the rise and fall of the tide as a source of power, other than those with which we are all familiar, but these attempts have not been crowned with conspicuous success. Of two such attempts, one at Havant was successful, and is said to be still doing useful work ; another at Cowes (Isle of Wight) was a failure partly on account of the heavy charges for the wharves with which it interfered, but chiefly on account of the inconvenience arising from its quiescence during the tidal interval, since no workman could be induced to remain at the factory where the machinery, actuated by the tidal installation, worked only for two periods of two or three hours a day, at constantly changing times ; the irregularity of the hours causing the non-success of the enterprise.

While it is well within the range of possibility that electric accumulators may be improved to such an extent, from a commercial point of view, that they would suffice to maintain any required load over the tidal intervals, still it is impracticable to count on such a contingency at present. For this reason the author will confine his remarks to schemes designed to obviate the difficulty of the tidal interval. But he wishes it to be distinctly understood that he does not think that quiescence during the tidal interval would prove an insuperable objection to the utilization of the tides as a source of power, for purposes other than the generation of electricity for schemes in which the output must be continuous.

The sum of the tidal intervals at high and low water is practically a constant, but there is often a considerable difference between the length of the intervals at flood and ebb tide. At Havre, for instance, the interval at high tide lasts for two hours, and the variation of level in three hours is only about 13in.

For the purposes of this paper the duration of the tidal intervals may be measured from the turn of the tide to such time as the rise above low water, or fall below high water, would permit of turbines being actuated by the water entering into an empty, or issuing from a full reservoir in which the tidal water had been impounded.

The intervals between flood and ebb tide are variable in different places, and the rate at which the tide rises and falls at any given place depends on its position as well as on the range. Commencing shortly after the period of low water, the rise is gradually accelerated for two and a half hours, remains nearly constant for the next hour, and then varies at a decreasing rate until high tide level is attained. For purposes of illustration only, it may be said that, in the case of normal tides, one-seventh of the total rise takes place in an hour and a half after low tide; five-sevenths in the three following hours, and the remaining one-seventh during the one hour and a half before high tide. Similarly, the fall of the tide proceeds in approximately the same manner. The point to be noted is that, speaking generally, the greater the rise and fall of the tide, the shorter the period that must elapse between high tide and the fall of the water to a definite number of feet below that level.

To take two extreme cases: the range of neap tides at Weymouth is 3¼ft.; in the Bay of Fundy, Nova Scotia, it is about 31¾ft. Assuming that the tide must fall 1ft. 7½in. before turbines can be operated from a reservoir filled to the level of high tide, a period of about three hours must pass before the water would fall to the required extent at Weymouth, while in the Bay of Fundy the period would not exceed 30 minutes.

To anyone who studies the rise and fall of the tides as a source of power it will at once be clear that the maximum range that can be counted on will be the minimum range of the tide. But to those who have not had the privilege of recording or examining tidal diagrams over an extended period, it may not be known that considerable difficulty may be experienced in ascertaining what is actually the least of low tides or the highest of high tides at any given part of the coast. At most of the important seaports tidal records have been made daily for several years, so that no difficulty need be experienced in verifying the constants given in the nautical almanacs, but where no records are available, continuous observations over an extended period will be necessary to establish the tidal constants. For most localities the tidal constants are recorded in the Admiralty Tide Tables, and as these are perfectly reliable, tidal observations may, to a large extent, be dispensed with. The height of neap tides on the coasts of the British Isles varies from 4½ft. off Dorsetshire to 31¾ft. off Portishead in the Bristol Channel. Generally speaking, the tidal range is low on the south coast between Bridport and Southampton, high on the south-west and south-east coasts. The average height of neap tides between Cape Cornwall and Swansea is 23ft.; between Portsmouth and Margate, 13ft.; and in the River Thames from North Foreland to London Bridge, 12½ft.

As will be seen later, the head available for power purposes, where the output is to be continuous, may be assumed at one-third of the range of minimum tides. As the head is the difference between water on the feed side of a turbine and the level of the delivery to the tail race, it follows that a turbine actuated by tidal water needs to be so arranged that the feed must, to be continuous, spring alternately from the tidal water and from a reservoir in which tidal water may be impounded. Since the power of turbines varies with the head and quantity of water available. and since the quantity of the tidal waters in this connection may be regarded as illimitable, it is evident that the power that could be developed from that source would depend on the quantity of water that can be impounded, that is, on the size of the reservoirs that can be formed to receive it. But it may be suggested that by taking advantage of the difference in time at which high tide occurs at different parts of the sea coast, it would be possible to eliminate the necessity of a reservoir by constructing twin installations in such situations that the tidal interval would be bridged and the continuity of the output assured.

The chief objections to such an arrangement are the greatly increased cost of maintenance due to duplicating the turbines and dynamos, increasing the length of the mains, and doubling the staff, and the necessity of damming the mouth of an estuary, making it valueless for the purposes of navigation. In such a humid atmosphere as obtains in England, too, the high voltage necessary for long-distance transmission would be impossible, and the output from the central station would be so much diminished that the practical efficiency of the twin installations would be seriously impaired. In addition to this, the central or distributing station would need to be more or less equidistant from either generating station, and hence the location of manufacturing centres that could be supplied would probably be limited to the Midlands. The author has not considered it expedient to study this alternative in detail here, for the reasons cited above, and because he has every reason to believe that there are vast stores of energy in the larger fresh-water rivers of England that could be utilized economically for the generation of electricity, more especially for the use of Midland manufacturing centres.

To return then to the matter of impounding the tidal waters in reservoirs, it is necessary, before proceeding, to outline the arrangement of turbines and reservoirs that the author believes to be practical and possible from an economic and commercial standpoint. Assuming for the moment that the turbines were placed in a chamber fitted with valves arranged so that the water might pass to them alternately from opposite directions, and that the tail race in like manner could be controlled by valves to permit the water to flow away in either direction alternately, it will be clear that if, by opening and closing one set of valves, water from a rising tide were free to flow from one side of the chamber through the turbines into a reservoir on the other side, by reversing all the valves when the tide had ebbed, water could be admitted to the turbines from the reservoir and would flow out into the tidal way.

But if the head is to be constantly maintained, more than one reservoir would be required ; for, when the tide had risen to its full height and the reservoir at the end of the tidal interval had been filled to a level below high water, equal to the head required for the turbines, then the tide would have to fall to a level equal to twice that head before the turbines could again be operated by water impounded in the reservoir. Hence, to maintain a constant head, two or more reservoirs would be required.

Now, since the only expense of forming a reservoir, for which no artificial floor is required, is the cost of the outer walls, and since the height and thickness of those walls would need to be as great for a small as for a large reservoir, it follows that the cost of wall per cubic foot of water impounded would decrease nearly inversely as the capacity of the reservoir.

This being the case, it is manifest that the larger the reservoirs are made the less costly per unit of power will be their construction ; and since more than one reservoir is required, it would, as a rule, be more economical to restrict the number by increasing the size as far as possible. It might happen that in a favourable position it would be possible to restrict the number of reservoirs to two, but under normal conditions it will be found that three are required.

The author has found that it is possible to vary the cycle of flow to and from the reservoirs in a number of different ways, but that the advantage gained by decreasing the area of the reservoirs through a complicated method of flow and delivery is more than compensated for by the simplicity of the arrangement that he has adopted. One of the methods alluded to is illustrated by the diagram Fig. 1. The method adopted by the author is shown by Figs. 2 and 3, reference to which is necessary for the clear comprehension of the following description. (See plate.)

The sequence of supply to and flow from the turbines may be described in the following manner :—

Commencing at the turn of the ebb tide, sluice gates in the outer wall of reservoir " A " are opened, allowing all the water remaining in it to escape into the tidal way ; at the same time valves in the wall of the supply chamber are opened to allow the water impounded in reservoir " C," the level of which is that of the last high water, to discharge through the turbines for a period of about 2¼ hours.

When the contents of reservoir " A " have been discharged into the tidal way, the sluice gates are closed. The tide having risen one-third of its range, the valves from reservoir " C " are closed, and other valves in the outer wall of the supply chamber are adjusted to allow the tidal water to become the source of supply to the turbines for a period of three hours and twenty minutes, during the whole of which time the water flowing from the turbines passes to reservoir " A " through valves in the side of the supply chamber. When the above-mentioned period of three hours and twenty minutes has elapsed, the tide will have risen to its full height, and the valves permitting the tail race to pass to reservoir " A " are then closed, while those giving access to reservoir " B " are opened.

In the outside wall of reservoir " C " a series of gate valves is provided, which allow the tidal water to flow into that reservoir and fill it up again to high tide level. Directly after the flow from the turbines has been diverted to reservoir "B" the sluice valves in the outside wall of reservoir " A," referred to above, are again opened to permit of that reservoir being filled up to tide level, after which they are again closed. The tidal water continues to flow through the turbines into reservoir " B " for a period of about 2¾ hours, until it has fallen to one-third of its range, when the valves admitting water to that reservoir and from the tidal way are closed, whilst those in the wall of the supply chamber from reservoir " A " and those permitting the tail race to pass out into the tidal way are opened, and remain open until, after a period of 4¼ hours, the tide has ebbed.

In the outside wall of reservoir " B " a hinged gate valve is provided, which permits of the contents of the reservoir being discharged into the tidal way, so that it will be empty when the tide has completely ebbed.

By referring to Fig. 3 it will be found that the working head from reservoirs " B " and " C " varies from the full range of the tide to one-third of that range, and since the power of the turbines is dependent on the product of the head of water and its quantity it is evident that with an increased head fewer turbines will be required to maintain the peak load, and that the area of reservoirs " B " and " C " may be less than would be necessary if a uniform minimum head were maintained.

It will be seen from the above description and from the diagrams, that to obtain a continuous output of power by this method a very heavy expenditure is involved. Three large reservoirs must be constructed, and a supply chamber connected by valves both to the tidal way and to the three reservoirs ; and the necessary valves, with electric apparatus to operate them from the power house, and a series of hinged gate or flap valves in the outside walls of the reservoirs, must all be provided.

It will also be recognized that the problem of utilizing the rise and fall of the tide for power purposes offers few engineering difficulties, so far as the principles are concerned, but that its practical solution depends on the choice of the site and on the economy of construction, or, in other words, on the design of the details. The real difficulty lies in the question of cost, of how to provide the necessary structural work without crippling the enterprise by excessive expenditure of capital.

The author has not found any records of a really systematic investigation of the question of cost, but has been told that the late Lord Kelvin gave it as his opinion that the cost of the embankments necessary for the formation of the reservoirs would be too great to admit of the utilization of the tides as a source of power. Whether this opinion was based on his own investigations or in regard to any particular scheme submitted to him the author is unable to say, but in the face of such an opinion it would be rash to assert definitely that the fear of the prohibitive cost of the reservoir walls is unfounded. The author has gone very closely into the probable cost of about four tidal installations, and has submitted his estimates to friends, accustomed to the consideration of such estimates from a financial point of view, and has uniformly been told that they are sound and that the interest on the capital expenditure would be sufficient to justify the outlay. They made one reservation, however, that their knowledge of financial matters evidently warranted, namely, that such an undertaking would not attract capital unless its financial supporters could see their way to making 100% at least

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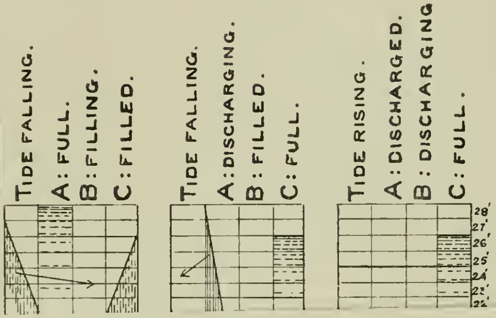
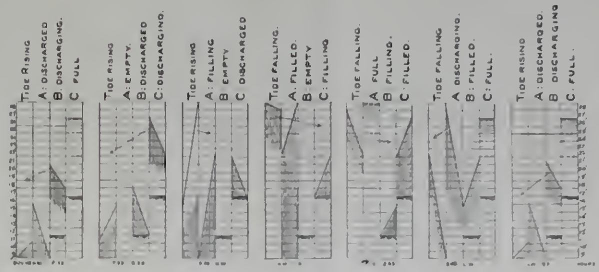
L OF THE SOCIETY OF ENGINEERS (INCORPORATED),

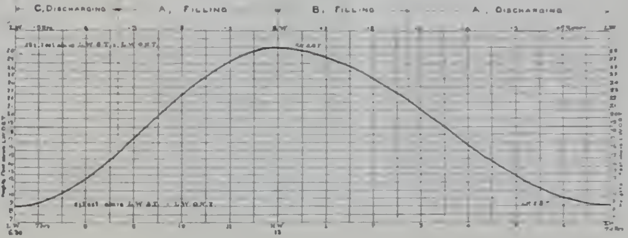
May, 1913.





FEED TO TURBINES ALTERNATIVE METHOD.

FIGURE : 1.



TIDAL DIAGRAM

FIGURE : 2

FEED TO TURBINES METHOD ADVOCATED.

NOTE *The arrows indicate direction of flow*

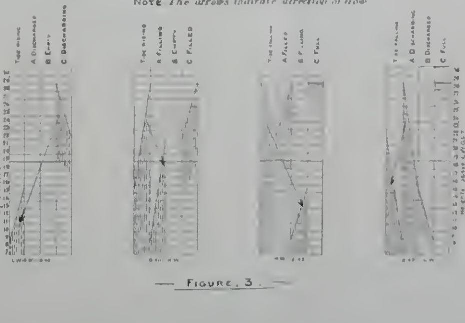


FIGURE. 3.

on their own outlay. From the financiers' point of view, no doubt, this is a reasonable demand, but it is hardly one which would appeal to the ordinary investor, who would generally be content with 7% interest on his capital if he could get it on a perfectly sound investment. Be this as it may, from the engineer's point of view the question of justifiable capital expenditure on commercial works, which he recommends, is limited to four points :—

(*a*) That the works are necessary to the fulfilment of a known requirement.

(*b*) That they will be of a character sufficiently permanent to fulfil the purpose for which they are designed.

(*c*) That the advantage accruing from the provision of the works may be sufficient to justify a sinking fund large enough to amount to the value of the capital expended at the end of a period not exceeding 50 years in the case of a permanent structure.

(*d*) That the income to be derived from the undertaking will be sufficient to pay a reasonable amount of interest on the capital expended after deducting all annual expenses and charges.

If an engineer is able to make reasonably sure that these requirements will be fulfilled by his designs, then he is justified in recommending the expenditure of the capital required for the construction of the works.

Now, the author has found that to make a close estimate of the cost of so vast an undertaking as that under consideration, detail surveys are absolutely necessary, and continuous tidal observations are desirable, while a knowledge of the vested interests likely to be affected in the neighbourhood of the installation, is essential. To make such a comprehensive investigation not only would it be necessary to spend a considerable amount of money, but at least twelve months would be required for its completion. Not being in a position to afford either the time or money for such investigations, he has been forced to content himself with rough estimates, allowing a very wide margin for contingencies, but otherwise, so far as is possible, based on actual designs for the structural parts of the work and on covering estimates for the valves, turbines and electric equipment, based on quotations from two or three firms of high repute. As an additional safeguard he has made no allowance for the reduced height of the walls of reservoir " C," but has estimated the cost of the walls as though the section were uniform over the entire length at a maximum depth. This he has done to avoid the risk of under-estimation, as the cost of these walls seems to be the determining factor of the problem.

The system he has adopted in the design of the walls is a modification of that which will probably be more generally adopted within the next few years than has hitherto been the case, viz., trestles of ferro-concrete. The arrangement proposed in this case is that of ferro-concrete trestles, each weighing between 20 and 30 tons, having the outside posts grooved for the reception of slabs weighing from 10 to 15 tons apiece.

The edges of the slabs are formed with a rounded V groove on the bottom and a similar rounded V projection on the upper edge ; the joint between them is made either with neat cement plastered in the groove before the slab is lowered into position, or with a stocking bag filled with neat liquid cement, in which case the slabs would be grooved top and bottom. The joint between the trestle post and the end of the slab is made with neat liquid cement.

The trestles are deposited in position, by means of a crane, in a trench previously excavated or dredged for their reception ; the slabs are next placed in position and grouted in, and then, when two or three bays are ready, the space between the two slab walls is filled in with earthwork, the top of which is protected with a layer of concrete about 7in. thick, and lightly reinforced with expanded metal. This layer of concrete is intended to serve the double purpose of protecting the surface of the filling and of binding the tops of the trestles together, so that when complete the sides and top of the earthwork core will be completely enclosed and protected by a skin of ferro-concrete. The cost of a wall or faced embankment formed in this manner has been exhaustively considered, and has been found to work out at £34 5s. per yard run, with a height of 50ft. from the foundation to the top, inclusive of the cost of setting. The earthwork filling may be of sand or other convenient material, which could as a rule be obtained from the inner side of the embankment wall by means of a grab, and as the consolidation will be satisfactorily effected by the action of the tidal water, it has been estimated at a rate of 2s. per cubic yard in the price given for the finished wall.

These and the following prefatory remarks are necessary to the comprehension of the rough estimate that is used later to illustrate the author's reasons for submitting the proposition with which this paper ends.

It has before been pointed out that the cost of the installation will vary nearly inversely as the capacity of the reservoirs, but though this is true in the case of installations for which the site has been selected, it is not true when applied to the comparative dimensions of two or more installations where the tidal range differs. Since the minimum head of water for the turbines is determined by the minimum range of the tide, and since, as the minimum range of tide increases, the maximum range increases more, it is evident that with an increase of the minimum head there will be a much greater increase in the height of the requisite embankment or reservoir walls. Hence it is clear that the greater the minimum range of tide available, the greater must be the power capacity* of the completed installation to cover the cost of construction. As a matter of convenience a formula based on the tidal range may be used for getting an approximate idea of the output in horse power for any particular location. Such a formula may be used as for preliminary investigations, and the subsequent investigations by trial and error can be much simplified by its assistance. The author suggests the following empirical formula for the purpose :—

Let S = the range of spring tides in feet.
,, N = the range of neap tides in feet.
,, P = the minimum economical horse-power of the installation.

Then $P = S + N \times 400$.

This seems to give a fairly close approximation to the minimum economical horse-power required for any particular ranges of tide, but it must not be forgotten that the local peculiarities of the site will be the determining factor, and that though it is better to get some idea as to the minimum size of the installation at the outset, it is essential that the figure so obtained should be regarded as falling within certain limiting values that can only be determined by exhaustive investigation.

In the case the author has selected for purposes of illustration the site is in the Bristol Channel, a site where the range of neap tides is 20ft. and of spring tides $38\frac{1}{2}$ft.

Using the formula given above—

$P = 400\ (20 + 38\frac{1}{2}) = 23{,}400$ H.P.

But as it is desirable to take the worst case, the author has based his estimates on an installation of a total capacity of only 20,000 H.P. for neap tides.

For reservoir " A " (see Fig. 4, p. 124) the efficiency of the turbines has been assumed to be 77·5%, as the head will vary very slightly, but in that of reservoirs " B " and " C," where the working head will vary considerably, the efficiency has been assumed to be 75%. The detail calculations of the several areas of the reservoirs and valves, being of a purely elementary character and taking up a considerable amount of space, have been omitted ; the results can be easily verified.

The area required for reservoir " A " with a minimum working head of 6ft. 8in. will be equal to the quantity of water required for the turbines per minute, multiplied by the time occupied in

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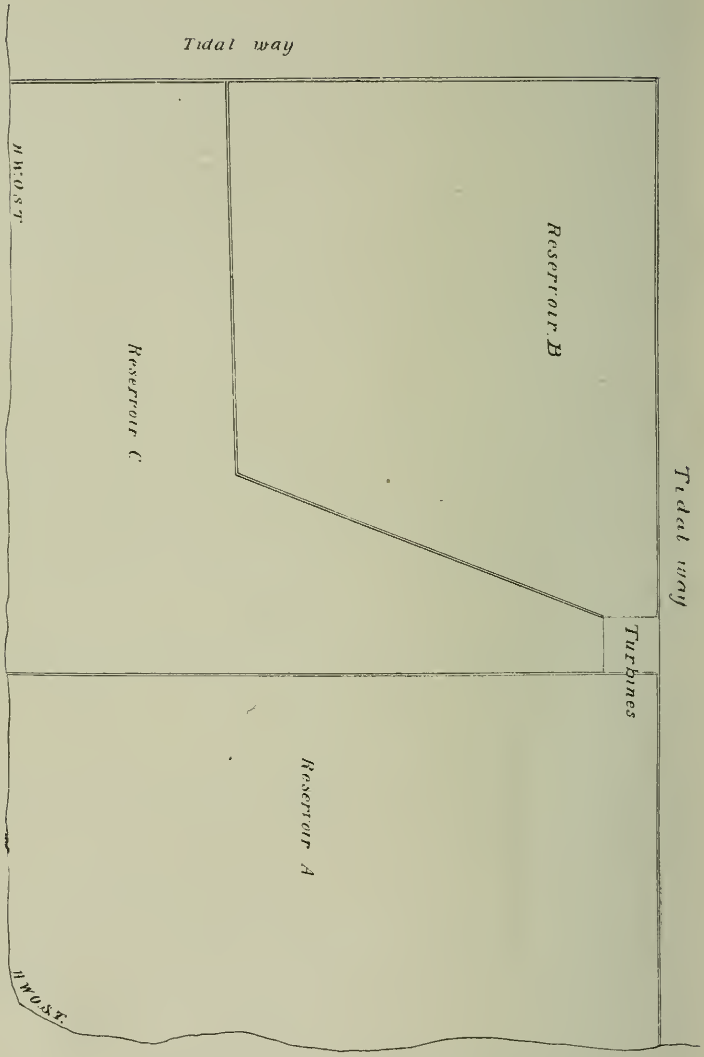
* For the purposes of this paper it has been assumed that the electricity will be supplied in bulk, and hence the value of the load factor has been estimated to be very high. See estimate of demand, page 127.



— Sketch Diagram: Reservoirs, etc. —

— FIGURE, 4. —

discharging 1ft. in depth of its contents during the longest period in which it serves the turbines, namely, 4 hrs. 25 min. (see Fig. 2), or, say, 1,996,000 c.f.m. × 20 min. =39,920,000 sq. ft.

Similarly the area of reservoir " B," with a mean working head of 12ft., will be 28,359,367 sq. ft., and of reservoir " C," with the same working head, the area will be 23,203,118 sq. ft.

The area of the valves giving access to and delivery from the supply chamber must be sufficient to permit of the maximum flow of water passing through them at a maximum velocity of 5ft. per second. Hence, since the maximum quantity is found to be 1,996,000 cub. ft. min., the area of each set of valves in the walls of the supply chamber must be 6,653 sq. ft. Of these valves six sets will be required, two of which are required for the passage of water to and from the tide ; two for the passage of water to and from reservoir " A " ; one to give access to reservoir " B " ; and one for the delivery from reservoir " C."

In addition to these valves there will need to be sluice valves in the walls of the three reservoirs to permit of the escape into the tidal way from " A " and " B," of the water remaining impounded after the minimum head is lost and to give access from the tide to reservoir " C." The area required for these valves will severally be :—12,293 sq. ft. in the outer wall of reservoir " A " ; 1,948 sq. ft. in that of reservoir " B " ; 2,125 sq. ft. in that of reservoir " C."

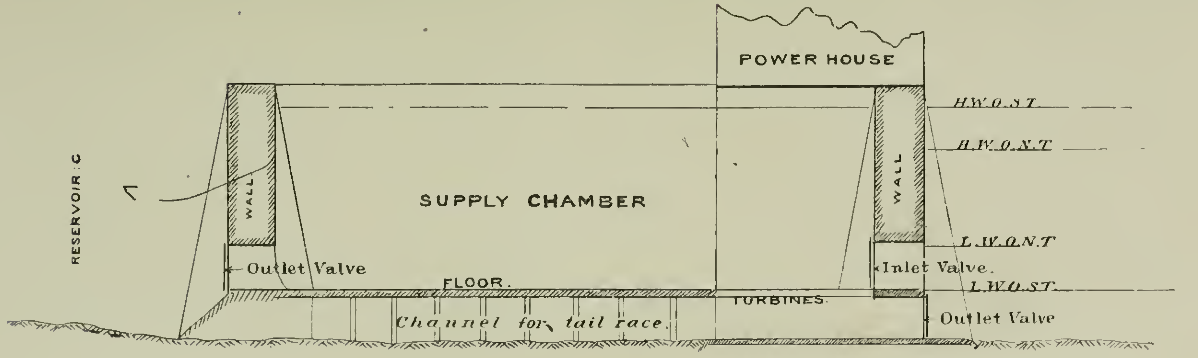
The area of the supply chamber is defined by the length of the walls required for the valves, and in the case under consideration works out to 490,000 sq. ft.

Since the area of the supply chamber is also that of the channel provided for the water flowing to and from the turbines, either to the reservoirs or to the tidal way, it is necessary to double it by a horizontal partition or floor, beneath which the tail race may pass, the feed water to the turbines being free to travel over it. This floor may be constructed quite economically by forming it of square concrete slabs, lightly reinforced and supported at the corners by ferro-concrete piles, the joints between the slabs being made in neat Portland cement. The level of the surface of the floor will coincide with that of low water level of ordinary spring tides. A sketch diagram of the section of the supply chamber is given in Fig. 5 (see next page).

The power house must be designed with a view to as great an economy as is consistent with the permanent character of the structure. In addition to the accommodation required for dynamos, switch gear, &c., space must be provided for step-up transformers, a fitting shop, an oil store, sleeping and living rooms for the resident staff, and an office. It may also be found desirable to provide cottages on shore for the workmen employed. The structural and other details of the installation

FIGURE; 5.

SECTION OF SUPPLY CHAMBER: SKETCH DIAGRAM.



must to a large extent depend on the character of the site ; but except in rocky or very hard ground the system proposed for the construction of the walls will be common to every scheme. Moreover, provided the details are carefully worked out with a view to economy, as well as to durability, they do not affect the estimate to any very serious extent.

The rough estimate for a tidal installation based on hypothetical data as regards many of the items must of necessity be very loose ; and in the following estimate the sums included for the purchase of land and for professional fees are based on what the author considers likely to cover those items rather than on figures that he has been able to obtain as a guide. The question of land is difficult, but it has been assumed that all that will have to be purchased is a strip one chain wide extending over the whole land face of the installation above the high water line of ordinary spring tides.

ESTIMATE *for a Hydro-electric Installation of* 20,000 *H.P., where the range of neap tides is* 20*ft. and of spring tides* 38*ft.* 6*in.*

Description.	Quantity Unit.	Rate.			Cost.	
		£	s.	d.	£	£
Legal and professional ..	—	—			20,000	
Land	—	—			10,500	
						30,500
Reservoir walls	12,203yd. lin.	34	5	0	417,953	
Walls of supply chamber	933yd. lin.	95	0	0	88,635	
Floor of do., including all labour	46,667 sq. yd.	1	16	0	84,001	
Walls at valve openings	571yd. lin.	93	0	0	53,103	
Power-house, foundations	1,000 sq. yd.	5	0	0	5,000	
Do. superstructure ..	600,000 cu.ft.	0	0	7	17,500	
Valves to supply chamber and walls of reservoir "A"	52,210 sq.ft.	1	0	0	52,210	
Valves, walls of reservoir "B" and "C" ..	4,073 sq.ft.	0	15	0	3,055	
Contingencies, 10% ..	—	—			72,146	
						793,603
Valve-motors, &c ..	—	—			10,000	
Turbines and accessories	—	—			60,000	
Dynamos and electric equipment	—	—			35,860	
Electric cables	—	—			20,000	
						125,860
		Total, say			..	£950,000

It has been already stated that the cost of all the mechanical apparatus is based on covering estimates, and therefore no sum for contingencies is added for these items.

Two methods are commonly practised for raising capital for an enterprise of this nature. In one the capital is raised by subscription from investors; in the other by raising a loan to be repaid with interest in a predetermined number of equal instalments. The latter method is that adopted in the case of municipal undertakings, which, though an extremely costly way of raising money, must be considered in this connection.

The cost of the Board of Trade unit of electricity depends on the annual charges that have to be met, as well as on the maintenance charges, so that the method of raising the necessary capital has an important bearing on the initiation of a costly enterprise such as that under consideration.

It is estimated that the annual and maintenance charges on the installation, exclusive of all charges for local sub-offices, sub-stations, &c., will be as follows :—

	£
Wages, salaries and stores	5,789
DEPRECIATION.	
Motors and electric apparatus, 10% ..	4,586
Turbines and accessories, 5%	3,000
Electric cables, 3%	2,600
Valves, 5%	763
Total	£16,738

To this must be added the annual investment of equal amounts as a sinking fund, or insurance charge, which in the case of the capital being raised by private subscription, may be assumed to accumulate at the rate of 3½% per annum.

On this assumption, and limiting the period of this annual charge to 50 years, a sum of £7,252 3s. must be set aside annually to secure at the end of that period an amount of £950,000, the capital required for the construction and equipment of the works.

Adding this amount to the annual charges for the items specified above, namely £16,738

Sinking fund	7,253
The total annual charges amount to ..	£23,991

or in round figures, £24,000.

Leaving for the moment the question of annual charges, those relative to the possible supply and demand have next to be considered, that is, the capacity of the installation relatively to the demand for electricity. (See footnote, page 123.)

The general question of the demand for electricity will be referred to in the concluding remarks, but at this point it is necessary to make some reasonable assumption as to the demand that might be expected under the existing conditions of the market, and by taking a percentage of that maximum demand, to arrive at that which could be reasonably counted on.

Of the 365 days in the year there will be 52 or 53 Sundays, the same number of Saturdays, and about 7 holidays.

Assuming that the demand in 24 hours of working days will be equivalent to a peak load of 15 hours, and that the demand on Saturdays will be one-half, and on Sundays and holidays one-third of this amount ; then the number of hours per annum in which the demand would be equivalent to the assumed maximum peak load will be :—

259 days at	15 hours	3,885 hours.
53 ,,	7½ ,, ...	397 ,,
60 ,,	5 ,, ...	300 ,,
	Total.. ..	4,582 ,,

The capacity of the installation is 20,000 H.P., or nominally 14,920 kilowatts, but as there will be a certain amount of leakage or loss of electricity on the mains, 25% must be deducted from this figure, so that the effective capacity of the installation must not be considered to exceed 11,190 kilowatts.

But it has been estimated that the maximum demand will not equal the total capacity of the installation for more than 4,582 hours per annum, that is—

11,190 K.W. × 4,582 hours = 51,272,580 B.T.U. per annum.

Hence, the supply being fixed by the maximum demand, the cost of one Board of Trade unit would be equal to the amount of the annual charges divided by the annual output in those units.

It has been estimated that if the required capital were raised by private subscription, the total annual charges would amount to £24,000, so the cost of one B.T.Unit would be :—

$$\frac{\pounds 24{,}000}{51{,}272{,}580} = 0\cdot 1045\text{d.}$$

Again, assuming that the actual demand would fall short of that which has been taken as a maximum by 20%, then the cost per B.T.Unit would be 0·1045d. × 1·25 = 0·1306d.

This cost represents an annual expenditure of £24,000, or £2 10s. 6¼d. per cent. per annum on the capital outlay.

Hence, to make a clear profit of 7½% it would be necessary to fix the minimum selling price at 0·5029d.

Even supposing that the capital expenditure has been slightly under-estimated, still these figures are sufficient to show that if the selling price per B.T.Unit were fixed, say, at a mean price of ¾d., there is strong presumptive evidence in favour of the success of the undertaking from the investor's point of view.

But if the undertaking is regarded as a municipal enterprise,* the necessary capital would be obtained by means of a loan that must be repaid by annual instalments of the interest on the whole amount, plus that amount which, accumulating at compound interest at a predetermined rate, would at the end of a definite period amount to the sum originally lent.

In the case under consideration this period may be fixed at 50 years. The various annual charges would then be :—

Repayment of Loan

Say 4½% on £950,000	£42,750	
Annual repayment (on a basis of 4½% for fifty years)	5,323	
		£48,073
Maintenance charges, &c.		16,738
Total annual charges ..		£64,811

The cost per B.T.Unit would, in this case be :—

$$\frac{\text{£}64{,}811}{51{,}272{,}580} \times 1\cdot25 = 0\cdot38\text{d. nearly.}$$

In this case, too, if the selling price per B.T.Unit were to be fixed at ½d. there would be no risk of loss.

It would probably be raised as an objection to these figures that the author has not allowed in the estimate for the installation of sub-stations with their necessary equipment of step-down transformers, high and low-tension switch-gear, &c ; and while he is quite sensible of the addition to the capital expenditure that these items would involve, he is unwilling to complicate the whole question of the utilization of the tides by entering into the cost of those details that are common to almost all electric power schemes. By including a fairly large sum for cables he has, in his opinion, done all that is necessary to indicate the outlay in this direction ; were he to have done otherwise it would have been necessary to examine closely into a number of other points that are really outside the province of this paper.

They are outside the province of this paper because it is submitted as a general proposition rather than as a definite scheme for a particular locality. One of the difficult problems which engineers have to solve in this country is how best to conserve the enormous advantage to our industrial population of an unlimited supply of cheap fuel. The supply of coal seems to spring from an inexhaustible source ; oil, though its price has risen recently owing to the greatly increasing demand, shows few, if any, signs of diminution of supply, and it is probable that as the oilfields in Russia are developed, the supply will equal, perhaps exceed, the demand. But since oil is not a material produced in Great Britain, and since the best substitutes for oil would appear to be a by-product of the coal industry, it seems eminently desirable to discover some rational method of relieving the demand for coal, which is so likely to increase. Coal is one of the most important of the national assets, and though the demand does not seem likely to exceed the supply for a long time to come, still the coalfields do not represent more than a finite quantity, which in course of time is liable to exhaustion.

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* This hypothetical case is adopted for purposes of illustration, and not because it is the only method employed by municipal authorities to obtain the capital they require.

The industrial competition between nations will steadily increase, and, speaking broadly, that nation is best equipped for the struggle which can command an economical and unfailing source of power for its factories in time of peace or war. While the British Isles owe so much of their prosperity to this advantage it seems mere folly to neglect any other source of power that is available ; even though, as in the case of water power, it is limited in extent. Germany, hardly better provided than England in this respect, has commenced to develop it, while the United States and Switzerland have already obtained a very large amount of power by the development of their natural advantages in the same direction.

England, so far as can be seen, has never realised her potentialities in this respect, or, if she has realised them, has never made a serious effort to discover their extent by a careful investigation of the matter. In the author's opinion, the few rivers with which he is fairly well acquainted, namely, the Wye, the Usk and the Severn, could each be made to contribute many thousands of horse power now running to waste, for the use of the nation.

The tides in many suitable localities should also be regarded as a national asset, for it could be proved by a trial installation that the cost of the reservoir walls would not be a fatal obstacle to their utilization as a source of power, and if this were recognized it would not be long before the capital required for the necessary works would be forthcoming for railways, etc.

Now, if the water power of the country were fully developed it is probable that, as time went on, electricity being the most convenient and economical source of power both for factories and for railways, the demand would increase until it equalled the supply, and hence the basis on which the above estimate was made is reasonable.

In conclusion, it is submitted that, not only can the tides be utilized economically as a constant source of power, but that, taken in conjunction with the power that could be derived from fresh water rivers, their utilization would be a great gain to the commercial and industrial prosperity of the British Isles.

Discussion.

The President in moving a vote of thanks to the author said that they had listened to Mr. Battiscombe with very great interest and would tender him their best thanks for the paper he had laid before them. Mr. Battiscombe at the end of his paper had mentioned as a recommendation of his proposals the desirability of having some other source of power in order to relieve the strain on our coal resources, and with the present price of coal, which was apparently rising, perhaps this might become even more desirable in the future, but it seemed to him (Mr. Valon) that the author's scheme must be judged by the cost of power generated by using the tides as compared with the cost of power generated by the use of coal, and this was the question which really laid at the root of the matter. It did not seem to him that the author had dealt with that question quite so fully as he thought might have been desirable. The author alluded to it but he did not make any direct comparison.

To his mind the author was very optimistic in regard to several matters in his own estimate. For instance, he took a load factor of 80 per cent., but if they were going to take a load factor of that magnitude they would have a very low generating cost if they obtained their power from coal.

It seemed to him that the load factor, whether in the case of a bulk supply or whatever it was, must depend eventually on the rate at which the electricity was used. That, he should think, would make the load factor that could be expected rather different from that which the author gave.

Then again, with regard to the author's estimate for land, of course £10,500 might be sufficient for land ; on the other hand they all, those who had had to do with public undertakings, knew that the estimate might be a long way out. The author assumed he had only to buy the exact area of land he required at what appeared to be the present value, but probably when he came to negotiate he would find that the price would go up very materially.

So far as the mechanical difficulties were concerned there was no question, he supposed, that if it paid, it was quite possible to generate power from the tides. The details of how the author proposed to do it, he (Mr. Valon) confessed he found a little difficult to follow, although he had no doubt the author was quite clear in his own mind, and probably it was quite clear in the paper.

He would conclude his remarks by asking them again to pass a hearty vote of thanks to the author.

Mr. Adam Scott said he had not come prepared to say anything about Mr. Battiscombe's interesting paper, because he had not seen it until he came into the hall, but he should like to say how much he was interested in the subject, and he knew that Mr. Battiscombe had given a very great deal of time and thought to the study of the subject. Probably it was the class of work which he had to do when he was employed in his (the speaker's) office, which led Mr. Battiscombe to give his attention to the subject. At any rate, he congratulated him on having put before them a very interesting and able paper. For his own part he thought it was a subject of study, which might be very usefully amplified. As to the question of water powers in general we have done very little in this country, and the Government had done nothing towards ascertaining data regarding water power possibilities and resources. If they were to look abroad, at the United States and Canada and into the Government publications of these countries, they would find that they had spent enormous amounts of money and time on this subject, and had given in those publications the most interesting details. He thought our own Government should be approached and asked to take up the subject of the water power resources of the country in a really practical way.

There had been no full or systematic studies made, and he quite agreed with Mr. Battiscombe that there was an enormous amount of water-power running to waste now, especially on the West Coast.

With regard to power from tidal waters in particular, it was a very old subject of investigation and one which had never been satisfactorily settled. He meant that it had never been brought to a really practical test, and he supposed the reason was that it had never been possible to do so successfully from a commercial and financial point of view. Personally he was inclined to think that, at present, it was hardly possible to look upon tidal energy as a main source of power, but it was perfectly possible as a supplement to other sources of power, steam, and gas, and oil ; and he thought as a subsidiary power it might be brought into use in many cases. But it had to be remembered that there would be certain periods—assuming cases with say one or two reservoirs—at times of slack water, at high water, and at low water, when the plant would be stopped altogether, probably for two or three hours, as there would be no head ; certainly at very high spring tides there would be no head. Mr. Battiscombe proposed to get over this by increasing the number of reservoirs, but this also meant increasing the cost. Notwithstanding that difficulty he thought it was very desirable that steps should be taken to utilise the power that might be obtained from the tides, wherever this could be done advantageously.

He fancied that Mr. Battiscombe's estimate of nearly a million pounds for a 20,000 horse-power installation, was rather high. It came out at something like £47 10s. 0d. per horse power. But assuming that such a plant was installed, and set to work, there would be in addition the expense of conducting power to any distance. Supposing they wanted to bring power, say from the Severn to London, it would mean a very heavy expense which he thought would be almost prohibitive. But apart altogether from that, he should like to bear testimony to the very able paper which Mr. Battiscombe had put before them. He hoped that the author of the paper might be able to carry his investigations further, and wished him all success in working out the matter.

Mr. Percy Griffith said their Society generally congratulated itself, and it might in this case again congratulate itself, upon giving an opportunity for the introduction of schemes which, at the time being, might be, comparatively speaking, untried novelties. It was, however, necessary that novelties should be ventilated and discussed before they were carried to the experimental stage. The subject before them that night was a peculiarly fascinating one in this little island of ours, because if they were going to utilise the tidal effect on the seashore, it was not an unimportant factor that in this island we had, he supposed, a larger seaboard in lineal dimensions proportionately to our area, and probably even to our population, than any other portion of the inhabited globe. The author had suggested that this rise and fall of the tide on our very extensive seaboard should be utilised for the economical transmission of electric power. He had not suggested any figure, but probably he would be able to indicate to thèm some sort of theoretical distance which should be placed between the various installations to utilise the whole of the tidal power available on our coasts.

While admitting that the subject was extremely fascinating and that it was well worthy of further consideration, and if possible, experiments on a small scale, he was bound to suggest some points which he thought the author might deal with in reply to the discussion and which, if satisfactorily explained, would facilitate the consideration of the whole subject.

The first one was this :—He had had some experience of works situated on the seashore. In this case, the works were above high water mark, and so far the boundaries of the property had not yet been assailed by even the worst storms, but when he told them that a few hundred yards away the sea wall had quite recently been broken down by a storm, he thought they would agree that it was a matter of serious anxiety to him lest the next big storm attacked the property he himself was interested in and at one fell swoop demolished an undertaking which had entailed a very considerable outlay of capital. The author had suggested a scheme involving a capital outlay of something like a million pounds, and he wanted to ask him with reference to the construction of the reservoirs, whether the seaward wall would be able to resist, not only enormous wave power, but timbers and floating debris which might be projected with terrific force against the wall in stormy weather. The author had not given them any details as to his foundations. Work on the foreshore was very special work, and while he did not claim any special experience in it, he knew enough to remind the author that it was most expensive. The bulk of these walls were below high water level, and the outer wall, he took it, would be entirely below water, and he was wondering whether the author had gone into the design and cost of such a wall. He had only given them the price per foot run, and without further particulars it was impossible to criticise the estimate. No doubt the author had gone thoroughly into the details of what he had assumed to be the normal conditions under which these walls would have to be constructed, and could give some further information on the point.

He would like to refer, in passing, to wave action. It would be very fascinating to be able to use that very destructive wave power, to subdue and harness that dangerous and enormous force, thus making their harbours into power-producers by means of wave-action, and turning that destructive implement of nature to the use and service of man. He thought they would all welcome the suggestion.

He would like to refer to the question of municipal loans, That was a matter he had had a little experience in, and the author had assumed that for municipal enterprises as suggested it was possible to get a loan for 50 years for the whole of this work. He would say broadly that, for machinery, loans could not be obtained for a longer period than 15 years ; he thought that that was a standard adopted by the Local Government Board, although, possibly, in a private Bill, a longer period might be obtained, but he did not think it would be considerably longer.

For the rest of the work, he very much doubted if 50 years would be obtained. He should hardly consider sea walls as coming within the scope of the term "permanent works." In his view they might be anything but permanent. He would say generally with regard to municipalities undertaking works of this nature that they did not go in for experimental novelties, but would let private companies undertake them, wait until they were paying a good dividend, and then buy them up. The Local Government Board would hardly sanction a municipality venturing on an undertaking of this kind.

He would like to know the diameter of each of the valves that the author had referred to, and how they were to be operated. He was greatly interested in the paper, and wished to offer his thanks to the author for presenting it to them.

Mr. Henry C. Adams said he would have preferred that the author should have devoted more space to the engineering part, even if it meant curtailing the financial portion. Although the financial question was important this was an entirely new subject to them as engineers, and they wanted first to be satisfied that the undertaking as an engineering problem was feasible. When they had decided that, it would be time to enquire whether it was a commercial practicability. There was no question, of course, that there was a vast amount of power available, and all they were concerned with was how it might be utilised. He must confess he really did not fully understand how it was proposed to work the system ; his questions, therefore, were in the hope of eliciting information, rather than to throw doubt on the feasibility of the scheme.

The author said that the sum of the tidal intervals at high and low water was practically a constant. He assumed that by tidal intervals was meant the periods of high and low water respectively during which the variation from the maximum and minimum level did not give sufficient head to work a turbine. He quite agreed that those intervals were more or less constant at high and low water of any one particular tide but they varied very considerably, and were shorter at spring tides than at neap tides. Mr. Battiscombe had properly taken the minimum range of the tide as the basis upon which he worked, but unfortunately the minimum range of the tide was during about one week only in June, being what were called the " bird " tides. Those tides were particularly small neap tides, and as it would never do to have an installation which would not work during even one week of the year, such especially low tides meant that the amount of power that could be relied upon from the installation would be very limited. In so far as they were exceptional, those bird tides were comparable with the equinoctial tides which we got twice a year, but the neap tides, being the low ones, were those that governed the matter. Then the author said that there was often a considerable difference between the length of the intervals at flood and ebb tide. He (the speaker) assumed this meant that the turn of the tide did not coincide with the middle of the tidal period, and, if so, that was one thing in which he did not follow the author. He did not think in practice there was very much difference between those two portions of the intervals. He had had an opportunity of taking a very large number of tidal diagrams and he found the difference, if any, was really negligible compared with the differences of time and level which one was always getting by reason of wind or other special circumstances. He quite agreed with Mr. Battiscombe that it was very necessary to take special tidal observations for any particular work on the coast. The Admiralty tide tables were very useful and very accurate for the ports to which they referred, but if they got 10 or 15 miles away from that port probably the character of the shore varied and the circumstances were very different.

As regards the sites of the reservoirs it seemed to him that it was absolutely essential to have a very large area of flat foreshore. The area of these three reservoirs which Mr. Battiscombe proposed was nearly four square miles ; that was an enormous area, and it was only on the sea coast, where there was a flat shelving shore, that anything like that area could be obtained. He did not see how reservoirs of that capacity could possibly be constructed in order to utilise the vast sources of energy in the large fresh water rivers of England, and a different system was necessary.

The Bristol Channel had absolutely the greatest range of tides of any place in the United Kingdom. That meant, therefore, that the author's calculations were not based on average conditions, and that there was only one place that this scheme as sketched out could apply to, and everywhere else the system would be less economical.

The author proposed to generate a large amount of power—over 50,000,000 B.O.T. units in a year. The greater the amount of power generated and sold the more pronounced the financial success of the scheme, but there were very few places on the coast where that amount of power could be used, and although doubtless if power were cheap new works would be set up to use it, in the meantime the interest on the capital lying idle in the tidal scheme would cause it to be unremunerative for many years after.

Mr. Battiscombe quoted the formula he gave, as to the horsepower which might be obtained from one of these installations, as an empirical formula. He (the speaker) would like to know whether the author had any data for that formula. To prepare an empirical formula one must have numerous facts and various cases before them, and must analyse those facts and thus get an empirical formula which fulfilled the conditions. In the nature of things it was out of the question for Mr. Battiscombe to have had a large number of examples to get data from. He did not see either why the author should add together the range of the spring tides and the range of the neap tides.

He supposed the valves would be gate valves, and assuming they were 10 ft. high those in the large reservoir would occupy a total length of about one-quarter of a mile. He did not understand at what level in the wall they would be fixed, but they would each have to be opened quickly and the whole of them within a limited period. He thought the mechanical and electrical difficulties in the way of actuating such valves would be very great indeed, especially as a lot of the mechanism would have to be on the exposed sea face of the wall.

Mr. Adam Scott asked Mr. Battiscombe if he knew of any single case where tidal power was now in use or at work in this country or elsewhere. He was not referring to fresh water power, but solely to tidal energy. He had seen a notice of a scheme on the Continent where it was intended to have a reservoir with an area of 4,000 acres, by which scheme it was hoped to produce power at about a farthing a unit. Then there was a small scheme proposed on the Dee, but he did not know whether it had been begun ; there again they hoped to produce power for about a farthing a unit.

Mr. H. C. H. Shenton thought that some speakers had been rather severe upon the author as regarded the difficulties in the construction of these reservoirs. They had overlooked the fact that at many places round the coast enormous embankments had kept out the sea for a very long time, a thing much more difficult of attainment. He instanced Holland and its dykes. It did not seem to him to be at all impossible that walls which would serve the purpose of retaining sea water should be constructed at an economical rate, neither did he see any particular reason why these walls should necessarily be constructed right on the sea front ; surely it would do equally well to have them at some little distance inland. There were plenty of areas in this country where the land was below sea level and below O.D. At such places it was obvious that dykes similar to those used for reclamation works would serve to retain water required for power purposes.

It certainly ought not to pass the wit of man to make use of the force of the tides. The power existed and there must be plenty of ways of making use of it. Imagine that the supply of coal gave out. Under such conditions engineers would soon produce all sorts of contrivances hitherto undreamed of for utilising wind power and the power of the rivers and the tides. The only reason that nothing practicable had been brought forward hitherto was that we had a source of energy at hand that could be made use of more easily under existing conditions. But whenever the time came that the coal supply failed there could be no doubt that use would be made of the tides. There existed a power that was obvious and it was merely necessary for engineers to turn their attention to it in order that a financially satisfactory scheme should be evolved. But this was not likely to occur just yet, owing to the fact that a different method of producing energy existed, to work with which all the machines in the country were designed, while none were as yet made to be worked with power produced by the tides.

Mr. C. Humphrey Wingfield in a written communication said that he had read the paper with very great interest. The problem of utilising the power manifested by the motion of the sea had been an attractive one to inventors from very early times and many devices had been invented, some of which had been put to work with considerable success. They might be divided roughly into two classes; namely tidal motors, to which the present paper was confined, and wave motors in which the undulatory motion of waves was made to actuate floats, punkah-like paddles, and other devices which gave motion to pumps etc., usually of comparatively small size.*

It had often been proposed to work tide mills by mounting very large floats or pontoons in such a way that their rise and fall with the tide gave motion to machinery of which the power was to be transmitted electrically or otherwise to a distance; but, when seriously considered, the cost proved to be prohibitive and one investigator came to the conclusion that a float "as big as a house" would give about one cat-power.

The only method of obtaining power on a large scale economically which had so far been proposed was by means of impounding reservoirs, the flow of the tide into or out of which actuated water-wheels or turbines during from $\frac{1}{2}$ to $\frac{2}{3}$ of the period of ebb and flow respectively.

It would be remembered that Sir Frederick Bramwell in 1872 stated before the British Association his belief that this method could be advantageously applied in the neighbourhood of the Bristol Channel. The commercial aspect of this suggestion was analysed shortly afterwards by *Engineering* in two leading articles which would be found on pp. 175 and 191 of Vol. XIV. (Sir F. Bramwell's proposal was reported on page 121). The result of the investigation, with coal at the then ruling prices, was to show that, under the assumed conditions, a tide motor could not compete with a gas engine.

The only other important discussion of tidal motors of which Mr. Wingfield was aware would be found in two articles on pp. 214 and 233, Vol. CVII. of *The Engineer*, written by Mr. W. C. Horsnail, in the first of which photographs appear of three tide mills which had attained a certain amount of commercial success.

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* A fairly exhaustive classification of Wave Motors was published by Mr. A. W. Stahl in the Proceedings of the American Institute of Mechanical Engineers for 1892, pp. 438 to 506. It was reprinted on pp. 524, 537, 565, 576, 594 of the *Practical Engineer*, Vol. VI.

Another method of utilising tidal power was by causing the water to compress or rarify the air in closed tanks in which it rose and fell with the tide ; an example of which, invented by Mr. C. M. Walker, was illustrated on page 114 of the *English Mechanic*, for April 11th, 1884 (Vol. XXXIX.). He was not aware, however, that these schemes had ever reached any practical success.

He thought the author's proposed use of three tanks in order to obtain a more constant supply of power was most ingenious and, if his figures for cost could be relied upon, that he had succeeded in showing that there was a fair prospect of success commercially. He had not time to go into this part of the question himself, but he thought it would be of interest if the author could say shortly how it was that he arrived at a conclusion so much more favourable than that in *Engineering* already referred to, and whether, if similar range of tide, cost of labour and of material were assumed, his method of treatment would show a result more (or less) encouraging than the less detailed one adopted in the articles referred to.

Mr. Wingfield believed that owing to the great range of tide in the Channel Islands and their greatly indented shore line, these islands would probably present good opportunities for testing the author's improved arrangement of tanks etc.

He felt that everyone interested in this subject would feel with him that they are greatly indebted to the author for placing his novel proposals before them in so much detail and he hoped that he would have an opportunity of reducing them to concrete form.

Reply.

The Author, in reply, said that the question of the cost of a B.O.T. unit produced in the ordinary way by steam engines using coal as fuel was very fully gone into each year in *The Electrical Times*, from which he gathered that one halfpenny per B.O.T. unit was the lowest cost of producing electricity by means of coal and that this cost might be considerably over 2d. He believed that it was 2d. at Cardiff, and, as they knew, Cardiff was practically in the centre of a coal-field.

The President said he had taken a load factor of 80 per cent. That was true on an equivalent peak load of 15 hours and that made a load factor of less than 50 per cent. when they took 24 hours. He thought that when electricity was supplied in bulk there were a good number of supply companies that had a load factor of over 75 per cent.

With regard to the suggestion that he had under-estimated the cost of the land, the saltings or land immediately above the high water line of spring tides,—the kind of land they generally found when there was a very extended foreshore—would in no case cost more than £50 an acre. In his paper he had taken £200 per acre as the basis of his estimate.

He was very glad indeed to be able to thank Mr. Adam Scott for the very valuable experience he had gained in his office. Mr. Adam Scott had most generously given him every opportunity to work at sections of every kind of sea walls for two or three years.

Mr. Adam Scott had said that what was really wanted in a question of this kind was systematic study. The object of the paper was to try to induce someone who had leisure, money and interest, to take up and thoroughly go into the matter to see whether the figures he had given—which were of necessity extremely loose—were not really reasonable. It was only by systematic study undertaken preferably by a Government Department that these questions could be established. He hoped very much that the paper might have the effect of inducing someone to go into the question systematically.

With reference to the transmission of energy from the Severn to London he ought to say that he was not an electrical engineer himself, but he did not think it would be possible to transmit the electricity to centres more than 25 miles away from the generating station. He thought 5,000 volts was about the highest tension that could be adopted in England owing to the humidity of the atmosphere, and at a tension of 5,000 volts it would not be possible to distribute electricity economically at a distance of more than 25 miles, if so much.

Mr. Griffith had said that it would not be feasible to make embankment walls to withstand blows due to very heavy waves and timber, or other material, being thrown against them during storms. It went without saying that a very extended wall must be made economically, and if it were to be made economically, it must be made in protected waters. It would be absolutely useless to attempt to make a tidal installation in any place that would be exposed to violent storms and large waves. With reference to foundations, he had gone into that question and had come to the conclusion that they would be very small, comparatively speaking, and could be dredged during all states of the tides. If that were done, the dredger could be brought practically right in shore to do the whole work. The foundations would be dredged to about 5 feet below the level of the bottom.

With reference to wave action and the benefits which might be derived from utilising the vast forces that were brought into play by the movement of waves, he thought that if anyone would do as he had done and spend a day or two at the Patent Office and read through the specifications written by those who had an idea of utilising wave action, they would be very much interested and amused. He did not think it was possible under present circumstances for anyone to make use of waves economically. First of all there was, of course, the great drawback to the utilisation of heavy waves, that they very seldom occurred, and if it were necessary to wait for a storm before they could be used, it would be very inconvenient, to say the least of it.

Mr. Griffith also said that he had not covered the cost of depreciation of machinery. He had given a period of 50 years for the sinking fund, but had allowed from 5 to 10 per cent. for depreciation of machinery, which more than covered the cost of renewal at the end of 15 years ; the cost of the walls would, on the basis of the paper, be entirely recovered during the period of 50 years. With regard to the valves, they were not necessarily circular, but oblong in shape, and being counterweighted could be operated easily by electrical apparatus.

As to the tidal intervals, he regretted that he had failed to make it clear that he had used the term in its technical sense of slack water at ebb and flood tide. He did not think it was possible to take anything but the minimum tide as a basis for calculation.

Mr. Henry C. Adams said that he did not know what place could possibly be suitable for an installation of such a great capacity, but he would find that railways could utilise a much larger installation than was suggested in the paper.

As to the empirical formula, he had made a great number of estimates, and had gone carefully into them, and in his practice the formula worked out very nearly correctly.

Mr. Adams also said that the valves would all have to be opened at once. That was not quite so, because the turbines might be allowed to rest, and the load could be carried for a short period at such times by storage batteries.

Mr. Scott had asked if he could give any instances of tidal installations. The only two he knew of were those he mentioned in the paper, of which the one at Havant was, he believed, working satisfactorily. It was working a mill during either the flood or the ebb tide, but did not work it continuously. With regard to dykes in Holland, they were very large, and would, he was afraid, be unsuitable in the case of tidal installations.

In reply to Mr. Wingfield, he (the author) considered that engineering practice had been so revolutionised during the last thirty years by the improvement in building materials and plant that the cost of executing extensive works at the present time was lower than at the time the analysis of the commercial aspect of the tidal installation had been made, forty years ago.

The cost of sluice valves of a span of 40ft. or more was now trifling compared with that of the same work before the introduction of low head hydro-electric installations gave an impetus to that class of work. The enormous reduction, too, that could be made in the cost of embankment walls, by the judicious employment of a ferro-concrete matrix, now rendered practical a scheme that forty years ago, would have been too expensive.

But he did not claim that a tidal installation would be practical from a commercial point of view unless it were made of such a capacity that the cost per unit of power would be brought within certain definite limits, say £40 per horse power.

In the case of the Channel Islands, he had commenced an investigation of the site at St. Heliers, Jersey, and found that by using the Causeway as an auxiliary to an embankment, and by running another embankment from the head of Albert Pier to Fort Elizabeth, which would be fairly well protected by the Hermitage Breakwater, it would be possible to obtain sufficient power to light the whole of Jersey. But the details of this installation were quite different to those mentioned in the paper, and were not, on that account, applicable to the more general consideration of the subject that he had endeavoured to put forward.

He desired to thank Mr. Wingfield for the information given as to previous publications on the subject.

17*th June*, 1913.

VISIT TO CHINGFORD RESERVOIR.

A large party of members of the Society of Engineers (Incorporated) visited the Chingford Reservoir of the Metropolitan Water Board on Tuesday afternoon, the 17th inst., for the purpose of inspecting the reservoir and the Humphrey pumps that are installed there. Permission for the visit to take place had been kindly given by Mr. W. B. Bryan, M.Inst.C.E., Chief Engineer to the Metropolitan Water Board, and by the Pump and Power Co., of 38, Victoria Street, Westminster.

The reservoir has a capacity of 3,000 million gallons, an area of 416 acres, and 4½ miles of embankments, and water is raised from the River Lea by means of five Humphrey pumps, four of which have a capacity of 40 million gallons per day and the fifth of 20 million gallons per day, the lift being 25 to 30ft. The pumps, which are the invention of Mr. H. A. Humphrey, F.C.G.I., M.Inst.C.E., M.I.Mech.E., employ the principle of internal combustion, and have no moving parts except the mushroom valves. A column of water, forming part of the water pumped, acts as a reciprocating flywheel, and also as a piston, having four strokes in each cycle. An explosive charge is ignited nine times per minute in each pump, and 15 tons of water are delivered at each explosion. The visitors greatly appreciated the opportunity of viewing this novel and ingenious application of a well-known principle.

For a detailed illustrated description of the Humphrey pumps at Chingford our readers are referred to *Engineering* of December 13th, 1912, and February 14th, 1913, and also to *The Engineer* of March 14th, 21st and 28th, 1913.

RECONNAISSANCE SURVEYS.

BY LOUIS S. SPIRO.

The eye is an optical instrument of the greatest delicacy, and the phenomena of vision may be regarded as among the most complicated and most worthy of attention by physicists. The author does not propose to write a treatise on the physiology of vision and its theoretical developments, for volumes might be written on the subject, but mention will be made of some of the causes of deceptive appearances connected with engineering surveys.

Nowhere is the proverb "Appearances are deceptive" so true as in an apparently smooth or gently rolling country where the vision is easily deceived and seldom gives to objects their true relative proportions. The undulations are so gradual that their aggregate is rarely suspected, some long undulations being often much steeper than they appear. The lateral offset from the top of a ridge to its foot, if the latter flattens out gradually, will appear greatly exaggerated, while a slope of 1½ to 1 or 33⅓° when looked at from in front will be estimated by the eye at about 50°.

Again at a certain distance from a coast that represents many inequalities, if we attempt to draw the coast line as it presents itself to the eye, we shall find on verification that although the horizontal dimensions may have been correctly sketched to a certain scale, the vertical angular objects have been represented on a scale about twice as large.

In the case of a rushing waterfall, if it is regarded fixedly for two or three minutes and the gaze is then suddenly turned to the adjacent rocks, the latter will appear to move from top to bottom. In a rapid river such as the Rhine above the fall at Schaffhausen, the current is noticeably more rapid in the middle of the river than near the banks. Here, if one looks at the centre of the stream for some time and then suddenly turns his eyes towards the bank, it will appear as though the river were flowing back towards its source, which is a contrary movement to that given in the previous example.

Numerous other examples of optical illusions could be given, and before mentioning the causes to which these deceptive appearances can be attributed, a few words should be said about the "field of vision", by which is meant the angle beyond which light rays cannot enter the pupil of the eye. In man this angle is one of about 180°, but in the lower animals such as fish and birds, the field of vision is very extensive, the pupils being more prominent and the eyes set more towards the side of the head than in the case of human beings. For this reason the ostrich can see behind him, and fish can see in any direction without apparent limit. In any case distinct vision is always in the centre of the object viewed.

In a reconnaissance survey sketching by eye is often necessary and requires considerable artistic taste, as well as the ability to see and estimate distances and slopes.

If the following series of facts is borne in mind, it will be easier to avoid mistakes due to a wrong perception of objects :—

1. *The eye foreshortens the distance in an air-line and exaggerates a lateral offset.*

2. *The eye exaggerates the sharpness of projecting points and spurs and the degree of curvature necessary to pass around them.*

Remembering the above, the engineer should not accept a line as satisfactory because the gradients and curvature are within the maximum limits, but should satisfy himself that the line cannot be improved.

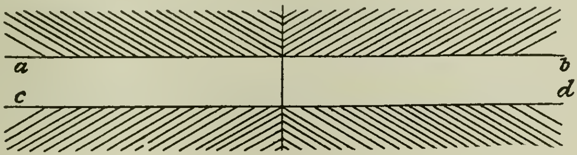
3. *Differences clearly perceived appear greater than differences equal to them but perceived with greater difficulty, either because they affect the observation only in an uncertain manner or that the mind fails to judge of them.*

This is the phenomenon of simultaneous contrast common to all perceptions of the senses. A man of middle height appears small beside a tall man, because at the moment it is impressed on us that there are taller men than he, and we lose sight of the fact that there are smaller. The same man of middle height appears tall beside a man of small stature.

4. *The appearance of objects is influenced by adjacent oblique lines.*

We perceive more distinctly the difference of direction presented at the intersection of two sides of an acute or obtuse angle than the direction that exists between one of the sides and the perpendicular which we imagine placed on the other side, but which is not marked.

The Romans were well acquainted with the influence of oblique lines. At Pompeii, fresco paintings are to be found in which the lines are not parallel, so that they satisfy the eye influenced by adjacent lines.



In the above figure *a*, *b*, and *c*, *d*, which are straight parallel lines, appear to bend outwards in the middle, the effect being caused by the oblique lines.

5. *Brightly lighted surfaces appear larger than they really are and the dark surfaces surrounding them appear diminished.*

This phenomenon comes under the heading of irradiation, and produces various effects according to the form of the figure lighted. When the light reflected from an object viewed is faint it can be seen more distinctly at night when we look away from it, which fact seems curious, the law being that an object is distinctly seen when we gaze upon it. As an illustration it may be remarked that when we want to see a faint and particular star it will at once disappear when we gaze at it and the best way to see it is to look away from it—a little to one side or the other. This does not refer only to persons suffering from astigmatism of the eye, who normally look to one side of an object when they want to see it distinctly, this tendency being due in their case to an error of refraction of the eye.

6. *Personal Equation.*—Another recognized defect of vision is that two persons may observe the reading of a levelling staff through the telescope of a level, under precisely the same conditions, and yet obtain somewhat different readings. Such a personal or individual equation being constant for the same person and affecting all his observations in the same manner, does not affect the accuracy of his work.

7. *Instrumental Parallax.*—Is another example in which the image of an object does not fall in the plane of the cross wires of a level or theodolite, and when the adjustment is made by one person it may not be correct for another. This is not a defect but an example of the phenomena of vision.

There are various other illusions that are due to a peculiar state of the atmosphere and to the unequal reflection and refraction of light, which are too well known to require explanation here.

When engaged on a reconnaissance survey, one must be in the best of health and humour in order to perform good work. In the healthy state of mind and body the relative intensity of the two classes of impressions on the retina are nicely adjusted—the physical and mental sensations are balanced. The latter are feeble and transient and in normal temperaments are never capable of disturbing or effacing the direct images of visible objects. When out of health there is practically a poisoning of the system and when one has a bilious headache objects are seldom seen in their true relative proportions because there is a pressure upon the blood vessels of the eye. The effects of fatigue and of a disordered stomach are also well known.

In conclusion, the importance of a reconnaissance or exploratory survey, as it is sometimes called, cannot be too strongly emphasized, and a good sketch not only gives a clear idea to the draughtsman, who can comprehend the detail more intelligently at a glance, but also replaces lengthy explanations that would otherwise be necessary.

TESTING CENTRIFUGAL PUMPS.

By Frank Harvey Hummel, M.Sc. A.M.I.C.E.

(*Member of Council*).

This paper describes a method of making a rapid test of a centrifugal pump. It would not be practically convenient for a pump of a large capacity, but in cases where a number of tests of small size pumps have to be made, and in laboratories, it has special advantages in reducing the time necessary for the tests.

In a pump test it is usually required to know for a certain speed, or a series of speeds, the variation of the discharge with the head.

This enables the pump horse power to be calculated for each discharge and hence from the observed power delivered to the pump,—the efficiency. The head and discharge for maximum efficiency can then be found for each particular speed. The usual method of running the tests, is to keep N the revolutions per minute, and h the head, constant, for a sufficient time to enable the discharge q to be measured by means of a notch or calibrated tank, then h is altered and another test made, and so on until a sufficient number of values of h and q are obtained for the chosen speed. Thus only one quantity is varied at a time, but in the following method h and q are allowed to vary together by pumping directly into a calibrated tank so placed relatively to the pump, that the water level in the tank is the head against the pump. Thus the total quantity pumped and the head are both given by the water level in the tank. This water level is continually rising, and if the level is read at regular intervals of time a curve connecting level and time can be drawn. This curve can be considered either as a time-quantity curve, or as a time-head curve, and the slope of the curve gives for a particular instant the rate of pumping, or discharge for the corresponding head.

Thus in one test, lasting a few minutes, all the data relating to the chosen speed are obtained.

The arrangement is shewn diagrammatically in Fig. 1.

T is the calibrated tank with a gauge glass or float to give the water level, measured above the level in the sump S.

Simultaneously with the water level the power taken by the pump must be observed, and the speed regulated. As most pumps are driven by an electric motor, this is easily done.

If the level in the sump varies or the delivery pipe is so long that the head lost in friction is not small compared with the total head, the level in the former must be noted and the latter estimated or measured. These quantities are usually quite small

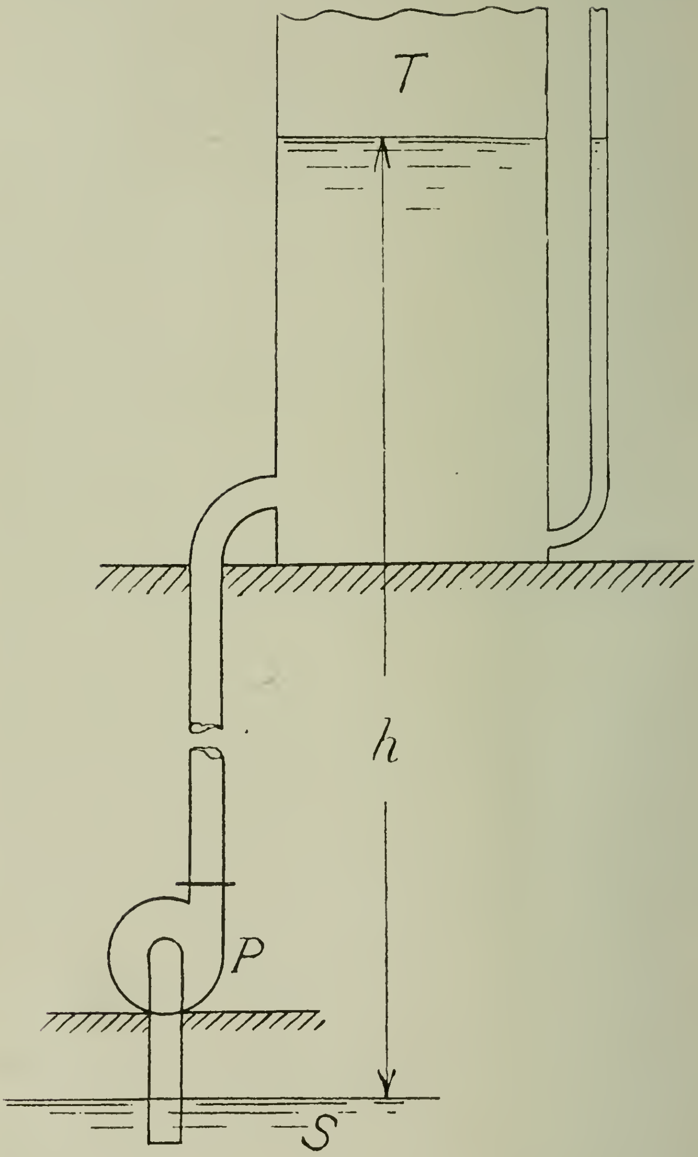


FIG. 1.

corrections, but they will be referred to later. For the present, the simplest case as already stated will be considered.

METHOD OF PLOTTING AND ANALYSING THE RESULTS.

This is best explained by taking an actual example, a 6-inch belt-driven pump running at 900 revolutions per minute.

The observed quantities are :—

Time.	Level in Tank above Sump Level. Head.	Kilowatts taken by Motor Driving Pump.	
Minutes.	Feet.		
0	25·01	15·4	Delivery pipe 8in. diameter. Tank cross-section 15·60 sq. ft. Weight of 1 ft. in depth of water in tank = 975 lb.
½	28·64	14·5	
1	31·8	13·5	
1½	34·49	12·6	
2	36·7	11·9	
2½	38·53	11·5	
3	40·18	10·8	
3½	41·18	8·8	
4	41·26	7·5	
4½	41·26	7·4	

These quantities are shewn plotted in Fig. 2. *a b* is the head or quantity curve, according to scale used, and *c d* is the kilowatts taken by the motor. At several points such as e_0, e_3, on the quantity curve, normals $e_0 f_0$, $e_3 f_3$ are drawn to the curve (by drawing the tangent first). The tangents of the angles between the normals and the vertical α_0, α_3, are proportional to q the rate of pumping in gallons per minute.

The subnormals $S_0 = Of_0$ and $S_3 = 3f$ are proportional to the pump horse power or kilowatts.

If on the drawing,

1 inch $= x$ feet
1 inch $= y$ gallons
1 inch $= z$ minutes

$$\text{then } q \text{ (gallons per min.)} = \tan\alpha \frac{y}{z}$$

$$\text{Power in ft.-lb. per min.} = 10\, q\, h \text{ (feet)} = 10 \tan\alpha\, h \frac{y}{z}$$

$$\therefore \quad \text{Power ft.lb. per min.} = 10\, s \frac{xy}{z} \text{ (}s\text{ in inches)}$$

$$\text{Horse power} = \tfrac{1}{3300}\, s \frac{xy}{z}$$

$$\text{Kilowatts} = \tfrac{1}{4420}\, s \frac{xy}{z}$$

The quantities are given in the following table, and they may be plotted on the curve Fig. 2 and the efficiency curve obtained, or they may be plotted in a separate diagram with discharge as base, as shewn in Fig. 3.

DEDUCED VALUES FROM CURVE.

In the drawing $x = 3{\cdot}51$

$y = 3{\cdot}45$ $\quad q = 625 \tan\alpha$

$z = {\cdot}55$ $\quad$ pump kilowatts $= 0.49.s.$

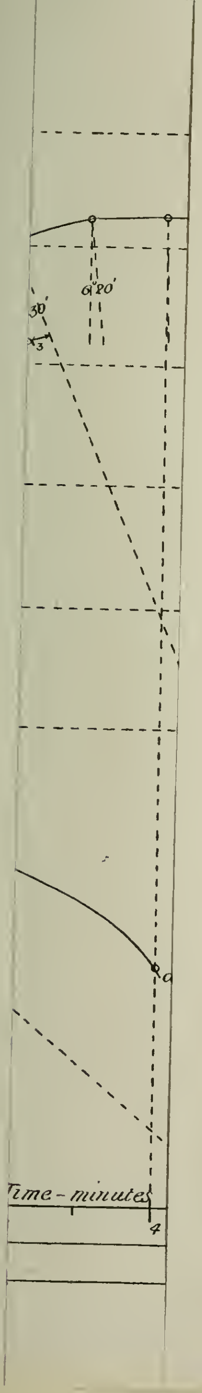
Time.	α	$\tan\alpha$	q Gallons per minute.	s	Pump	Efficiency η
minutes.	° ′			inches.	kilowatts.	
0	49·10	1·16	725	8·32	4·14	26·9
$\frac{1}{2}$	47·20	1·085	675	8·84	4·39	30·2
1	43·20	·94	590	8·44	4·19	31
$1\frac{1}{2}$	37·30	·76	475	7·57	3·72	29·6
2	32·20	·63	390	6·64	3·25	27·3
$2\frac{1}{2}$	28·10	·54	335	5·95	2·93	25·5
3	22·30	·41	255	4·75	2·32	21·5
$3\frac{1}{2}$	6·20	·11	69	1·37	·64	7·3
4	0·40	·01	7	·14	·07	0·1
$4\frac{1}{2}$	0	0	0	0	0	0

If for any reason a graphical method is not convenient, the values of q can be calculated from the observed times and tank levels, by taking the quantity differences for each minute or half minute, that is, by assuming that the points on the curve are connected by straight lines. The error is small, but the results are not displayed so clearly as by the graphical method.

Corrections.—If by reason of the variation in sump level or the friction of the discharge pipe, the level in the tank does not represent the total head on the pump, the Fig. 2 is plotted as before, and the angles determined, and from them the rate of discharge.

Fig. 3 is then drawn connecting discharge and the corrected head, and the power calculated as the product of the two. If the total head is measured by gauges at the pump, the gauges must be read simultaneously with the water level in tank, and for any value of the latter for which the discharge has been found the total head is then known. If this is not done the corrections must be applied separately. The manner of correcting for sump level variation is obvious ; it is directly added to or subtracted from the head. The pipe friction is equal to K $\frac{v^2}{2g}$, when v is the velocity in the pipe in ft. per minute, and as q has been already determined, v is also known, and therefore the head lost

TEST OF 6



TEST OF 6" CENTRIFUGAL PUMP.

900 REVS per MIN.

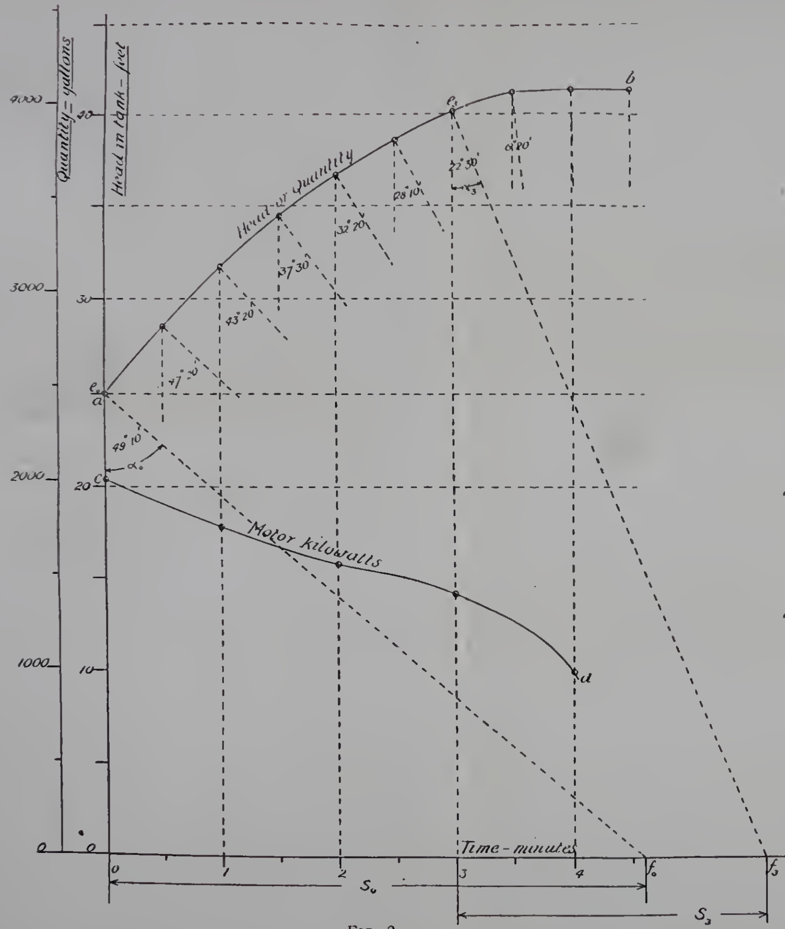


FIG. 2.

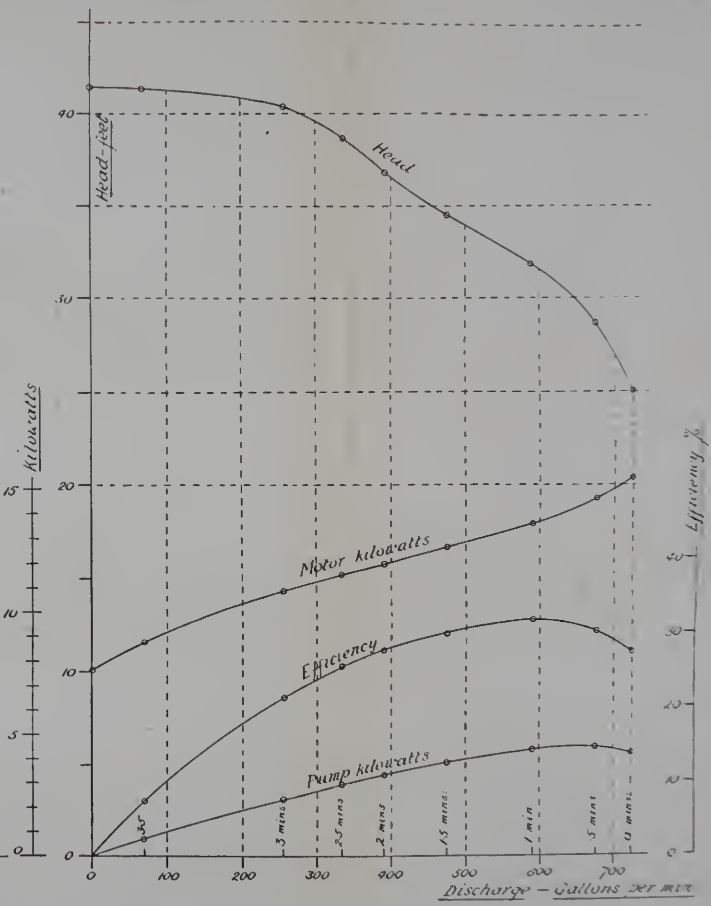


FIG. 3

in friction, if the constant K has been estimated or measured. This quantity is then added to correct the value of the head against the pump.

In an appendix the author describes a method of measuring the loss of head in a pipe and the constant K, by allowing water to discharge freely from the calibrated tank, through the pipe, taking a few readings of the water level and the time.

Practical details.—The head for maximum efficiency will not be lower than two-thirds of the maximum lift. That is to say, the tank should have a height of one-third of the lift, and be placed high enough to take the maximum lift. For high lift pumps the method could be modified by pumping into a closed tank, the pressure as well as the level being recorded. This would also have the advantage of requiring a smaller and shorter tank. With the open tank, for the experiment to last five minutes, a convenient size of tank is given by

$$\text{A (area tank sq. ft.)} = \frac{\text{Q (cub. feet per min.)}}{10}$$

APPENDIX I.

The estimation of the head lost in a pipe due to friction and obstructions, by discharging water through the pipe from a calibrated tank. If the pipe discharges into the air the head is measured above the centre of the outlet, if under water, from the surface of the water.

At any moment when the head is h feet

$$h = \frac{v^2}{2g} + h_l$$

when v is the velocity in the pipe in ft. per second and h_l the head in feet lost in friction.

Writing $h_l = \text{K}\frac{v^2}{2g}$ the equation becomes

$$h = (1 + \text{K})\frac{v^2}{2g} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (1)$$

The discharge in cub. ft. per second $= q = av = a\sqrt{\frac{2gh}{1+\text{K}}}$

If the head falls by dh in time dt

$qdt = \text{A}.dh$ when A is the area of the tank in sq. ft.

$$\therefore\ \text{A}.dh = a\sqrt{\frac{2gh}{1+\text{K}}}dt \text{ and}$$

$$t_2 - t_1 = 2\frac{\text{A}}{a}\sqrt{\frac{1+\text{K}}{2g}}\left(h_1^{1/2} - h_2^{1/2}\right) \quad \ldots\ldots\ldots\ldots\ldots\ldots (2)$$

If therefore while the tank is emptying readings of h and t are taken, a series of values of K or a mean value of K can be found.

The following table gives the results of an experiment on a 4in. pipe about 70ft. long with several bends discharging into the air.

Time.		h Level in Tank above centre of Discharge Pipe.	$\sqrt{h}$	$\sqrt{h_1} - \sqrt{h_2}$	
min.	sec.	feet.			
0	0	38·35	6·19	0·23	
0	30	35·51	5·96	0·23	$A = 15{\cdot}60$ sq. ft.
1	0	32·84	5·73	0·23	$a = {\cdot}0872$ sq. ft.
1	30	30·28	5·50	0·23	and
2	0	27·82	5·28	0·22	$K = 7{\cdot}70$
2	30	25·48	5·05	0·23	
3	0	23·19	4·82	0·23	
3	30	21·06	4·59	0·23	
4	0	19·02	4·36	0·23	
4	30	17·11	4·14	0·22	
				mean 0·228	

The uniform values of $\sqrt{h_1} - \sqrt{h_2}$ shew that the accuracy of the method is all that is necessary for practical purposes. The duration of the experiment and the rate of flow in the tank, was the same as in the previous pumping experiment, so that the same accuracy as regards the reading of time and head may be assumed for that case.

APPENDIX 2.

Pumping into a closed tank.

When the head is h in the tank (Fig. 1), and the pressure is atmospheric $= (P_a)$, let the tank be closed by a valve so that it becomes an air vessel, then at any other head h_1 the air pressure is $P_a \dfrac{H-h}{H-h_1}$ when H is the total distance from the sump level to top of closed tank.

The total head against the pump is therefore $h_1 + \dfrac{P_a}{w}\,\dfrac{H-h}{H-h_1}$

and as before $q = \dfrac{dh}{dt} A$.

THE NATIONAL CONTROL OF RIVERS AND WATERWAYS.

By Reginald Brown, M.Inst.C.E., F.S.I.,
M.Inst.M. and C.E., M.R.S.I.

The fifth report of the Royal Commission on Sewage Disposal, in dealing with the question of pollution of surface water, suggests the formation of a central administrative authority and of local rivers boards, and that their duties should include : The protection of water supplies from pollution and the collection of information as to available supplies and also as to the need for water in various parts of the country. The author would suggest that their duties should further include the control of rivers in their entirety—from the source onwards—so as to prevent, as far as possible, a repetition of the disastrous floods of 1912 by providing for proper outlets for the drainage of the country and the prevention of too tight training and restriction of the waterways.

Rainfall—beneficial when controlled, but disastrous when neglected—has probably never been more forcibly brought to notice than during August 1912, and the month will be remembered for many years as an illustration of the disastrous effects of excessive rainfall when provision has not been made for dealing with these extraordinary occurrences. Unless actually witnessed one can hardly realize the loss and suffering involved, such as was seen, for instance, in East Anglia and the Fen districts. Local authorities are every year expending large sums of money in laying down storm-water drains which discharge eventually into natural watercourses. The increase in population of a district means increase in hard, impermeable surfaces from which the rain is discharged at a much greater rate than when the area was purely agricultural. Then—the rainfall percolated into the ground, and went to feed underground springs ; now—it is got rid of as speedily as possible, and, worse still, the growth of a town generally gives rise to a restriction of the natural waterways by the erection of buildings close to the water's edge, and the spanning of rivers at the narrowest points by bridges. The course of many rivers is so tortuous that this restriction of the waterways gives rise to a very serious problem, and when it is borne in mind that the growth of towns is gradual, the difficulties of straightening the course become more serious year by year. Every little district through which a river passes cannot be expected to look far enough ahead, even from a financial point of view, to insist upon not only the straightening of a river bed, but also the prevention of the restriction of its waterway ; this is a wider question for the consideration of the country as a whole, and could very well be undertaken by a central authority. How many people realize the thought and expense involved in providing against flooding when they watch the rain falling in torrents and coursing down the street channels, disappearing from sight through the road gullies. There it all ends – so far as they are concerned—but if it happens that one single gully becomes blocked then the local authorities receive a reminder, more or less gentle according to the temperament of the writer.

The whole subject of flood prevention is so bound up with legislation that it may be of interest briefly to sketch the various legislative attempts made in the past to deal with this matter. Floods cannot be placed in the same class as earthquakes and tidal waves, inasmuch as these latter are beyond man's jurisdiction and control, whereas floods are, in many instances, caused by man's interference with nature. The first real Act dealing with the matter was passed so long ago as the reign of Henry VIII. Commissions were appointed with extensive powers as to taking measures for preventing floods and improving the state of rivers, the expenses incurred being recoverable from the riparian owners in proportion to the benefits derived from the works. In 1861 further provision was made as to the drainage of agricultural lands, in which the representative principle was adopted in the selection of persons to deal with arterial drainage. So long ago as 1877 a Select Committee of the House of Lords found that too many authorities existed in the control of any particular river from its source to its outlet, and recommended a simplification of governing bodies, but very little has been done to attain this object. The recurrence of similar floods to those of 1912 may again bring the matter forcibly home to our legislators, and as the matter is not a local matter in any sense of the word, but rather a national one, the conservancy of rivers, prevention of floods and such like ought to be in the hands of a Government Department or of a central Rivers Board. Speaking generally, the administration of English rivers is in a state of chaos. No doubt there are reasons why this has not yet been done—difficulties in propounding an equitable rating scheme, interference with prescriptive rights, vested interests and private property. Rivers to act as natural outlets should be kept free from weeds and other coarse growth. The beds should be straightened and widened and embanked where necessary, obstructive bridges, &c., should be reconstructed, and shoals should be cleared away. To show the disastrous effects of floods it is as well to take the two instances mentioned, viz., East Anglia and the Fens. It is not within the memory of living man in Norfolk that such an amount of rainfall has occurred as was experienced in East Anglia when Norwich, Lowestoft, Yarmouth, Beccles and the intervening districts suffered badly; Norwich, the capital, suffered most severely. It is almost incredible that this part of the country, having a low rainfall per annum, should have been visited, as recorded at Norwich, with a downfall amounting to about 6½ inches in one day of 24 hours. Realize what this means in a city like Norwich, the area of which is about 7,500 acres, and without considering the area of the watersheds of the Yare and Wensum, over which the rainfall is collected and discharged into the sea at Gorleston. It means that in Norwich alone some 4,875,000 tons of water must have fallen, equal to about 1,092 million gallons, or sufficient to fill a canal 33 miles long, 100 ft. wide and 10ft. deep. It must have been a black week indeed for Norwich—goods and passenger train services stopped, the city cut off from communication with any other town, the tramway service dislocated, the town in darkness, streets and houses flooded, telegraph and telephone services interrupted, trade practically at a standstill.

The other illustration referred to is that of the Fens. Thousands of acres were under water, and crops were ruined. The Eastern Midlands lying between the rivers Trent, Severn, and Thames are drained by four rivers, viz., the Witham, the Welland, the Nene, and the Ouse, all discharging into the upper end of the Wash. The area drained by these rivers is about 5,719 square miles, their total length being 416 miles and with their tributaries 872 miles. These rivers drain portions of the counties of Lincoln, Norfolk, Northampton, Cambridge, Huntingdon, Rutland, Bedford and Buckingham, and their sources are not more than about 30 miles apart. The country generally is flat, and the lower part of the watershed known as "the Fens" consists of alluvium and peat. The area of this part is some 668,000 acres, the greater part of which was formerly a vast morass, but is now a tract of valuable agricultural land, thanks to the efforts of early "adventurers," who undertook to drain and improve the land in return for a share of the acreage. Those who have been in the Fens and in Holland will have noticed a striking likeness between the two—both are practically at water level, and in both the country is intersected with miles of open ditches or dykes, from which the water is pumped into the rivers. It was to a Dutchman that the drainage of the Fens was originally entrusted, and it is a curious coincidence that a part of Lincolnshire is to-day called "Holland."

As the Fen drainage is the most important example in this country of improvement of rivers and reclamation of land it may be of interest to touch briefly upon the rivers in its area, although their incapacity during 1912 was proved in spite of the vast sums of money expended upon them.

The River Witham.—This river rises near Stamford, is 89 miles long, and has another 89 miles of tributaries. It drains an area of 1,063 square miles. The river enters the Wash near Boston. Hundreds of thousands of pounds have been expended by the various commissioners on this river for improving and keeping it in order. The lower part of Lincoln has been several times under water, and in 1876, when several of the interior banks burst, 40,000 acres of land were flooded, people were driven from their houses, and cropping destroyed to an estimated value of £100,000. Since that date also heavy floods have occurred, doing great damage.

The River Welland.—This river rises near Market Harborough in Leicestershire, is 72 miles long with tributaries 65 miles long. The area drained is 707 square miles, and the discharge takes place into the Wash, near Fosdyke in Lincolnshire. Extensive floods have occurred in the area drained by this river. In 1880 thousands of acres were submerged, and many villages along its course suffered in like manner.

The River Nene.—This river rises near Daventry, in Northamptonshire, and is 99 miles in length with 52 miles of tributaries, which all discharge into the Wash near Sutton Bridge. The area drained is 1,055 square miles. The Nene enters the Fens at Peterborough, and then divides into two branches, the old river joining the Ouse and the other through the Wash lands and Wisbech to the sea. From Peterborough to the sea it is nearly a new river, and it cannot be denied that it has been more altered by various works than any other. In spite of some half a million of money spent on the improvement of the main channel, the river is not satisfactory, thousands of acres of land along the valley being sometimes inundated. At Peterborough during flood time the streets adjoining the river are flooded, and people driven from their homes. At Yaxley, Ramsey, and other places in the Fens thousands of acres of land were under water in 1912, and the crops were ruined. The local papers were full of accounts of the awful harvest week of rain and flood, river banks shattered, and miles of waterlogged and ruined crops. From the 19th to 29th August, 1912, as much as 5in. of rain fell at Peterborough, and the register at the City Bridge over the River Nene showed a depth of water of 17ft. 6in., or about 8ft. above the normal. Taking an area of one million acres drained through the upper and lower reaches of the river at Wisbech, a rainfall of only ¼in. per day represents the enormous total of 25,000,000 tons of water to be got rid of, representing a canal 170 miles long, 100 ft. wide and 10ft. deep, or a much larger quantity than would be contained by the river and its tributaries.

The River Ouse.—This river rises within four miles of one of the sources of the Nene. Its total length is 146 miles, and with its ten tributaries is no less than 397 miles long. Its drainage area is 2,894 square miles. For the last 50 miles of its course it traverses a very flat district, and is in embankment, and it enters the Wash at King's Lynn. This river stands first in the amount of money expended on its improvement.

These rivers tap a very valuable and fertile agricultural region, and if made navigable for a considerable portion of their length might rank as main carriers of agricultural produce. Inland navigation has however, been seriously neglected since the advent of railways, which latter have diverted the traffic formerly "water borne," with the inevitable consequence that inland navigation has almost ceased; the works have gone to ruin for want of funds to maintain them, and shoals of weeds choke the channels. The rivers thus become in a far worse condition to discharge the drainage of the country than when left in their natural state, and in consequence heavy and disastrous floods occur. The number of private Acts of Parliament in force and the number of bodies of commissioners exerting jurisdiction over these four rivers alone, even when they pass through the Fens, is extraordinary, and at times it is almost impossible to define their powers and rights. It would lengthen this paper unduly to discuss the various works that have been done in different parts of the country for the improvement of rivers, both from the point of view of drainage and navigation, but the occurrence of disastrous floods on many of the English rivers, especially in flat districts and in towns, demands a remedy, and the author is of opinion that such remedy would best be applied through a central body or Rivers Board having charge of rivers and inland navigation for all purposes—drainage, water supply, prevention of pollution, training, improving, straightening, prevention of restriction of waterway, removal of obstructions, and, last but not least, rainfall records—and that until such measures are taken floods will occur to spread devastation in their wake.

The important questions to be considered in connection with the matter are the cost of the operations involved and the method of obtaining the necessary money. The two questions really go together, and before considering them it will be just as well to see what the suggestions mean.

NATIONAL CONTROL OF RIVERS FOR ALL PURPOSES.—The work of the suggested Central Board might be set out in the form given on the following page:—

CENTRAL BOARD.

- Administrative.
  - Records.
    - Rainfall
  - Navigable Rivers & Canals.
    - Rivers for Drainage purposes only.
    - Drainage into Rivers, Water Supply from Rivers, Pollution of Rivers.
  - Maintenance of Canals and Waterways.
    - Construction of new Canals.
    - Improvement of existing Canals and Navigable Rivers.
    - Improvement of Rivers (for drainage only).
    - Prevention of Pollution of Rivers.
    - Approval of Schemes for Sewage Disposal Works and Drainage Works when discharging into rivers.
    - Approval of schemes for Water Supply from rivers.
- Financial.
  - Nationalization of Canals.
  - Raising Money for Maintenance and Improvement of Canals, Waterways, and Rivers
  - Staff and Central office for the carrying on of the Board's work.

The first consideration, then, is the constitution of the Central Board. At the present time the work is carried on by several different authorities. Thus, rainfall records are kept, say, by the Meteorological Office, the information being supplied by various observers, voluntary and official, in different parts of the country ; canals are the property of and under the control of companies and in some cases local authorities, who maintain them out of the tolls exacted for their use ; navigable rivers, in some cases, are under the control of commissioners, who maintain them by receipts from tolls, licences, fees, and improvement rates ; rivers and streams for drainage purposes are in some cases controlled by commissioners, who maintain them by levying drainage rates on the land receiving benefit, whilst in other cases no control is exercised except by County Councils, who maintain county streams out of the county rate ; the prevention of pollution of rivers is in the hands of County Councils and other local authorities ; the water supply from rivers and streams is in the hands of companies and local authorities whose schemes are approved by river conservators, Parliament, and the Local Government Board ; schemes for sewage disposal and drainage have to be approved by the Local Government Board ; the erection of buildings near to and bridges over rivers and streams is in the hands of railway and other companies, local authorities and private individuals ; in the case of railway and other statutory companies power to erect bridges has to be obtained by Act of Parliament and local authorities receive sanction from the Local Government Board. Private individuals and others erect buildings, etc., in many instances on land adjoining rivers without regard to the restriction of the waterway. It is for the consolidation of all these interests that the author suggests the formation of a Central Board. This Board would, of course, have to be a legally constituted body, and the powers could either be vested in the present Local Government Board or a separate Government department created. A separate Board would find the work to be done enough to engage its whole attention, while the Local Government Board has already a sufficient number of duties.

So far as the financial aspect of the question is concerned, the first step is the nationalization of canals, the expense of which could be covered by exacting tolls from the users of the canals and navigable waterways. The maintenance and improvement of rivers could be met by a drainage rate over the area of land controlled by the rivers and streams, the incidence of such rate depending upon the assessable value of the land, etc., within the drainage area of the river or stream, and being levied and collected by the County Councils and paid over to the Central Board.

Although many other details have to be considered, the above gives a general outline of the powers and financial side of the question, and the author trusts sufficient has been said to indicate the feasibility and advisability of the formation of a Central Board.

PRECISION AND POSSIBILITIES IN ENGINEERING.

By Louis S. Spiro.

The extreme precision known as hair-splitting is of no great value in ordinary civil engineering work, the benefit derived from it being, as a rule, insufficient to compensate for the extra expenditure of time and money involved in its attainment. For instance, a line of levels twenty miles long in which the staff readings are taken to the nearest hundredths, will give nearly the same results on intermediate points, and about the same difference of elevation between the points at its extremities as a line of precise levels taken with target readings.

It is necessary to distinguish between accuracy, which is freedom from mistakes, and precision or refinement of measurement expressed in terms of the probable error. The importance of the work in hand should decide the degree of precision required. For example, tunnels are usually constructed by excavating from both ends simultaneously, the work requiring the most minute accuracy in all the surveying operations, so that when the headings meet there will be no appreciable discrepancy in the surveyed lines either laterally or vertically. In such a case both time and labour should be freely given to secure the highest possible precision. Similarly in extensive geodetic surveys great precision is necessary in adjusting the angles of the triangles so as to make them consistent with one another, by eliminating instrumental and other errors.

All the possible sources of error must be considered so that precautions may be taken to avoid them. In levelling, for example, the sources of inaccuracy include defects of adjustment in the instruments and the failure of the staffman to hold the staff truly vertical, while a microscopically minute jarring or settlement of the level is enough to vitiate the accuracy of the work. Moreover, the errors, due to curvature and refraction, resulting from taking backsights and foresights to staves at unequal distances from the level, may become considerable, even though the instrument is in perfect adjustment. Some engineers avoid all sights at distances exceeding about a quarter of a mile ; others prefer to do the work early in the morning or even at night, using plummet lamps to sight on.

The general construction of transit theodolites or tacheometers has been greatly improved of recent years. Such instruments are now much more rigid than formerly, and the weight is reduced by making the telescope supports or uprights of a single solid casting, which is less likely to get out of adjustment than the built-up form of support. The levelling screws are fitted with dust caps and an adjustment for taking up any wear that may occur. Instruments of this refinement read by micrometers to single seconds on both circles, such a high degree of precision in the manufacture of instruments having been thought impossible not long ago. A recent test with a 6in. tacheometer fitted with an extended telescope and an improved micrometer subtense stadia diaphragm, was found to give a resultant accuracy of 1/2,000th, or within 3ft. in the mile, with a very simple calculation. In comparing this method of measuring distances with the vertical arc method, it will be well to note that in the stadia method an uncertainty of 1 minute at a distance of 1,000ft. will be equal to an uncertainty of about $3\frac{1}{2}$in., while in the vertical arc method an uncertainty of 30 seconds in the vertical circle would produce an uncertainty of over 7ft. in a distance of 500ft., which is intolerable. In a traverse survey, if the work has been carefully carried out, the closing error should not be greater than the smallest reading of the instrument, thus showing the desirability of having as small a reading as possible. It is, however, important to note that the most accurate results are not necessarily obtained with the most refined instruments. For example, in order that the direction of a line may be determined so that a distant end shall not depart from its true position by more than one fifty-thousandth of the length of the line, the angle on which the direction depends must be measured to about the nearest 4 seconds. A theodolite giving a high degree of precision need not be used ; an instrument reading to 30 seconds will permit of an approximation to this result if the mean of three readings of the angle is used, while one reading to 20 seconds will, by a triple measurement, allow of a result even a little closer than the required one.

Again, a reasonably low-power telescope on a level or theodolite will generally give a better definition and more light than a high-power telescope. A telescope having an erecting eyepiece (showing objects upright instead of in an inverted position) entails some loss of light, and slightly curtails the field of view as compared with one having an inverting eyepiece. The latter has only two lenses, while the erecting type requires four, and as each lens absorbs some of the light rays that reach it, this means that in general, and to a limited extent, power and definition are opposed. In some cases telescopes are fitted with an additional lens within the body so as to avoid the necessity of adding a " constant " for tacheometrical measurements. This not only entails considerable loss of light, but also practically halves the effective power of the telescope.

Another case in which accuracy is an essential factor of success is to be found in the application of general formulæ to engineering calculations. Here, unless one weighs the different conditions and possibilities, and exercises care, good judgment, and often a little ingenuity, the required accuracy will not be obtained, especially when the formulæ are based on constant values of co-efficients or are deduced experimentally from special conditions. In some instances such as the formulæ for finding the discharge of water over weirs, unless the conditions are as nearly as possible identical with those from which the formula to be applied was deduced, the calculated result may be widely different from the actual value, except when, by good judgment or otherwise, the proper co-efficient is used.

Costly and embarrassing mistakes have been committed by neglecting such facts, which are often of such a nature that they can be known only by experience and observation. The projecting heads in a steel riveted pipe reduce its carrying capacity by much more than the decrease of the diameter due to the annular ring of rivets. A 42in. riveted steel pipe with a row of rivet heads inside 1in. in depth will have a less discharge than a smooth pipe 40in. in diameter.

The next subject of consideration is the physical possibilities presented by the art of the engineer.

" Impossible " is a dangerous word to use in our days with regard to future achievements in engineering science. We ride five times as fast as our fathers did, travel, weave, forge, and excavate better. We have harnessed Nature by artifice just as one bridles a wild horse, the great Assuan reservoir dam being an excellent example.

The greatest changes brought about in the nineteenth century customs are owing to the enormous progress made possible by the introduction of steam and electricity, leading to developments that the people of fifty years ago would have thought incredible.

So far as we know at present there are only two links connecting us with the planets and the stars. These are light, or in other words, the undulations of the waves of ether, and the attraction of gravitation. There is no absolute impossibility as to either or both of these being used in future for purposes of communication, for it has already been found practicable to convey an intelligible message along a ray of light, and since the discovery of wireless telegraphy it has been thought that by its means we might establish communication through interplanetary space by sending out steadily repeated waves with an interval between each set.

There are varieties of sound waves which bear very much the same relation to ordinary sound waves that the X-rays used in

Rontgen photography bear to the Hertzian waves used in wireless telegraphy. One of the most striking phenomena connected with the propagation of sound is that observable in whispering galleries. The exact cause that makes the whisper heard at considerable distances is still doubtful, but the explanation given by Lord Rayleigh is that the sound is carried by waves that differ from ordinary waves in that they creep round the gallery horizontally, and do not travel in straight lines. In his " Theory of Sound " the difference between these and ordinary sound waves is dwelt upon, and interesting conclusions are deduced. For example, he says, " The propagation of earthquake disturbances " is effected by the curvature of the surface of the globe acting " like a whispering gallery."

Marconi has shown that rays of light might be expected to have an adverse effect on the propulsion of electro-magnetic waves over long distances. He found that wireless signals could be recognised at night at a distance of over 2,000 miles, while in the daytime the utmost range was about 700 miles. He then reasoned from the fact that a body which is negatively electrified remains so longer in darkness than in the light.

Shortly after the discovery of the Rontgen rays, Professor J. J. Thomson, of Cambridge, found that if a negatively electrified body were placed in their path, its electrification was rapidly dissipated, which showed that the rays must consist of a stream of electrified particles ; and by mathematical analysis he found the ratio of the mass of each particle to its electrification. By experiments on the production of negative electrification by means of a glowing carbon filament in hydrogen, he calculated the ratio of the mass of the hydrogen atom to its electrification. He further concluded, by comparing his results, that the mass of an electrified particle in a beam of Rontgen rays was almost exactly the five-hundredth part of that of a hydrogen atom.

Professor S. P. Langley invented an apparatus of extraordinary delicacy by means of which he was able to prove that the light emitted by a firefly is unaccompanied by heat. The rays given out by the firefly were found to lie entirely beween the green and greenish-yellow rays of the spectrum, which are specially important for purposes of vision and are cold rays. He showed that of the rays emitted from an ordinary candle flame only 2 per cent. were light rays, the rest being heat rays.

Such statements in earlier times would have been received with incredulity, as has so often happened when a new-found truth has been formulated, but the spread of education and the growth of democratic ideas allow of scientific pronouncements being much more readily accepted in our own day. At one time Copernicus was alone in his conviction that the earth and the planets revolved around the sun, and Harvey was reviled by his fellow practitioners for stating that the blood circulates in the veins and arteries of living animals. Yet these opinions are now accepted facts.

The recent discoveries that have been referred to, and others no less remarkable, inevitably force one to the conclusion that the possibilities of development in engineering science are almost infinite in their extent, and we should be proud to belong to a profession that is concerned with the practical application, for the use and convenience of man, of the wonderful results that modern scientific research places at our disposal. When it is seen that ideas which not long ago were regarded as fantastic and impossible have become the commonplaces of everyday life, one will naturally hesitate to deny the probability of much greater developments in the future.

VACATION VISITS.

A visit was paid on September 2nd to H.M. New Stationery Office and H.M.O.W. Stores, now in course of construction at Stamford Street, S.E. Permission to inspect the works had been kindly given by Mr. R. J. Allison, A.R.I.B.A., who is responsible for the design of the building.

The new structure will be in two blocks, the larger in Stamford Street being the warehouse, and the smaller one facing Waterloo Road being the office portion. A short street, Bazon Street (formerly Bond Street) separates the two portions, but they will be connected from the level of the first floor and upwards by arched beams of 28ft. span, carrying a building 40ft. wide and forming additional space for the offices.

The following gives the general dimensions :—

Length of frontage to		Stamford Street	323 ft.
,,	,,	Cornwall Road	189 ,,
,,	,,	Doon Street	377 ,,
,,	,,	Waterloo Road	106 ,,
Average height of main fronts above footpath			77 ,,

Including ground floor and basement there will be 7 floors in the warehouse and 8 floors in the office block, including subground and basement. The height, generally, from floor to floor will be 11ft. in the office block and 10ft. 6in. in the warehouse. The total floor area to be provided is 480,000 superficial feet, or a total of, roughly, 11 acres.

Internal areas, of which there will be two in the office block and three in the warehouse, will be provided to light the interior parts of the building. The windows of the warehouse will be provided with steel sashes. The working of the warehouse will be carried on mainly by means of two electric lifts for goods at the platforms of the loading yards in Doon Street. There are also two lifts for passengers, one for the offices and one for the warehouse.

For the office staff a dining-room 55ft. by 23ft. will be provided on the top floor of the office building, together with kitchens, etc., specially fitted with steam and other cooking arrangements. In connection with this part a goods lift is provided for stores and for service at all floors from basment.

The drains inside the building will be of cast iron pipes laid under basement floor, and a complete system of heating by hot water under forced circulation will be provided.

The reinforced concrete work is being carried out on the Hennibique system. The following independent floor loads are allowed for :—

In Warehouse, Ground Floor	3 cwt.	per sq. ft.
,, other floors	2½ ,,	,,
In Offices, all floors	100 lb.	,,
In Roofs	65 ,,	,,

The floor slabs are 3½in. thick in warehouse, and 3in. thick in offices, and external walls generally are 4in. and 6in. thick. The boiler chimney will be also of reinforced concrete, 4ft. 3in. square inside, 110ft. in height, with sides 7in. thick at bottom and 5in. thick at top. It will be lined throughout with firebrick set 3in. clear of sides and built in sections supported by corbelling.

All columns have octagonal bases designed to distribute a pressure not exceeding 3 tons per square foot on the foundation. The front of office block, facing Waterloo Road, will be of Portland stone carried by the reinforced concrete columns and beams, mainly at level of sub-ground floor. The general contractors for the whole of the work are Messrs. Perry & Co. (Bow), Ltd.

On Tuesday, September 30th, by the courtesy of Mr. H. H. Dalrymple-Hay, M.Inst.C.E., a visit took place to the works connected with the extension of the Baker Street and Waterloo Tube Railway from Paddington to Queen's Park. A descent was made at the shaft situated near Kilburn Station, L. & N.W. Railway, and the visitors ,having divided in two parties, were conducted to the working faces. The tunnel linings are built up of cast-iron segments forming a tube 11ft. 8½in. internal diameter, the station tunnels being 21ft. 4½in. internal diameter. After the cast iron rings are in position the space behind them is grouted with lias lime so as to fill the voids completely. The work progresses at the rate of four rings, each 1ft. 8in. wide, per twelve hours, and the work is carried on continuously day and night. At the conclusion of the visit a vote of thanks was passed as a mark of appreciation of the courtesy shown by the representatives of the engineer and the contractors who were deputed to act as guides.

6th October, 1913.

ARTHUR VALON, M.INST.C.E., PRESIDENT,
IN THE CHAIR.

HIGHWAYS.

By CHARLES HAMLET COOPER, M.Inst.C.E.

ADMINISTRATION.

THE Highway Authorities of England and Wales include :—

51	County Councils.
75	County Boroughs.
249	Boroughs.
821	Urban District Councils.
657	Rural District Councils.
1	London County Council.
1	The City Corporation.
28	Metropolitan Boroughs.
1,883	

Each of these Authorities, with few exceptions, acts as an independent Highway Authority within its own district, controlled only by Government Departments and County Councils in carrying out work for which grants are made. Although three Government Departments, viz., the Local Government Board, the Board of Trade, and the Road Board, exercise certain functions in respect of highway authorities, none of these Departments controls such authorities as regards work paid for out of local funds.

As far back as the 18th century the inconvenience of such a system was realised, and a scheme for placing the highway authorities of the metropolis under the control of a central body was prepared early in the 19th century. Unfortunately, the idea was abandoned, and was not revived owing to public attention being then directed to railways.

The necessity then apparent for a central controlling body is far more pressing at the present time, when the traffic borne by highways has undergone such a radical change as that consequent on the introduction of motor-driven vehicles. This form of traffic, with increased speeds and loads, requires wider and straighter roads that so intersect as to allow approaching vehicles to view each other at the earliest possible moment, whilst the road crust must be capable of carrying the traffic to which it is now subjected.

It is impossible to effect these improvements in roads passing through the districts of various highway authorities, most of whom may be quite willing to accept a general scheme for improvement, whilst it is impossible to obtain the consent of the remainder of such authorities. Perhaps the most serious question is that of effecting improvements close to increasing centres of population, where building operations add immensely to the cost of subsequent improvements. The writer may be allowed to point to two cases. The first is that of High Street, Brentford,* which has a width of less than 30ft. from house to house. A Commission appointed by Parliament when reporting on the Great Western Road, in 1837, stated that fast coaches lost five minutes of their time in passing the short distance of the confined street that constituted the town of Brentford, and they proposed a road " avoiding the town of Brentford altogether." With such a recommendation on record the Brentford Council allowed two lines of tramway to be laid in the street referred to, on the condition that £5,000 was deposited for the widening thereof. The estimate for widening this street is at present some £700,000. In the other case, a strip of land 20ft. in width was offered for widening Streatham High Road, between Mitcham Lane and Streatham Station, at £120. The refusal of this offer has resulted in the shops built on either side being so placed as to leave insufficient space for the London County Council to lay double lines of tramway, so that this is the only portion of the road in which a single line exists. These cases are given to illustrate want of forethought on the part of highway authorities.

In order to obtain the land necessary for improving our highways every opportunity that arises should be considered and the land secured before building operations take place.

The writer has effected extensive widenings, the land for which was obtained free or at a nominal cost. If freeholders are approached at the proper time they are, as a rule, only too willing to effect improvements that tend to assist the development of their estates ; if these opportunities are lost, however, and the ground has subsequently to be acquired compulsorily, in most cases when valuable buildings have been erected, the price is very materially increased. There is little doubt that, under the control of a central body, many of the authorities who at present refuse to widen their highways on the score of cost, could be induced to do so.

Our forefathers in many cases provided space in front of buildings which would allow for the widening now required ; highway authorities have, unfortunately, in many cases allowed such space to be built over. Euston Road and the City Road are examples of such a policy.

The author has in mind the case of a highway along which a boundary dividing two districts lies. On the one side the District Council has kept back the buildings and obtained ground sufficient to effect considerable widening, whilst the Council on the other side has allowed buildings to be brought right up to the road, so that the cost of future widening will be almost prohibitive. This has occurred in a piece of road which forms the connection between a 55ft. road of the London County Council and a 100ft. road proposed by the Board of Trade.

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* Board of Trade Report on London Traffic, 1911, page 19.

The question of highway widening is a matter that can be dealt with only by a central body, who should prepare plans showing the lines to which buildings might be brought forward, and who should have the power to fix such line.

No more pressing example of the necessity for such a central body could be found than that of London and its suburbs, for within the last five years many millions have been added to the cost of effecting pressing street widenings, by allowing buildings to be erected on the ground required for such widenings. In Oxford Street the rateable value on the North side has increased over 90 per cent. in 10 years, mainly due to the erection of buildings in a street having a carriageway of from 36 to 52 feet in width and taking some of the heaviest traffic in London.

France has seen the necessity of providing for traffic requirements, and in Paris alone some £36,000,000 is to be expended to meet these requirements.

The central body should represent not only highway authorities but also the users of highways, especially for commercial purposes. The function of this body should not be confined merely to highways construction and maintenance, but should embrace the regulation of vehicles using the highway, including tramways, and the use made of the subsoil beneath the highway surface.

There does not seem to be the same aversion to the formation of a central body in other countries that there is in this. At the late Road Congress a section was devoted to the question of "Authorities in charge of the Construction and Maintenance of Roads.—Functions of Central Authorities and Local Authorities," in which nine papers were submitted from various countries, All were in favour of more centralisation, with the exception of the paper that dealt with Great Britain, written by eight authors, of whom only two were opposed to centralisation, and these were the representatives of the Rural District Councils Association.

The Road Board would appear the body best suited to exercise central control. Unfortunately, its powers are restricted under the "Development and Road Improvement Funds Act, 1909," which constituted the Board. Under Section 8 it was empowered—

(*a*) to make advances to County Councils and other highway authorities in respect to the construction of new roads or improvements of existing roads ;

(*b*) To construct and maintain any new roads.

Section No. 9 constitutes the Road Board a separate highway authority with full power with regard to roads the Board may construct. It is, however, very questionable whether such a Board should have executive powers such as are conferred by this section; and so far the Board has not exercised its executive powers.

With these limited powers and a limited expenditure of £2,184,314 it is extraordinary what improvements the Board has induced local authorities to effect. In fact, the very formation of the Board showed the highway authorities that unless they adopted better methods the fate of the highway warden awaited them.

At the late International Road Congress the surfacing of roads in this country was given as follows:—

	Miles.
Permanent pavements	4,000
Bituminous-bound roads	4,650
Water-bound macadam, tar-sprayed	16,000
Water-bound macadam	123,000
Unmetalled	2,857
Total ..	150,507

These are maintained at an expenditure of £15,465,668, or £103 per mile. To meet this expenditure we have—

	£
Tax on motor vehicles	358,000
,, petrol	546,000
Other Imperial taxes	1,608,000
Local taxation	12,953,668
	£15,465,668

Of the total expenditure on highways 83¾ per cent. has to be found out of local rates.

The motor vehicles using these highways are as follows:—

Pleasure motors	80,468
Commercial ,, ...	14,000
Motor omnibuses	4,000
Public automobiles	27,260
Motor cycles	63,680
Total motor vehicles ..	189,408

Rural districts naturally object to pay 83¾ p.c. of the upkeep of their highways, the wear of which is mainly due to traffic foreign to their district.

LAW.

The law relating to highways is founded on the Highways Act of 1835, which repealed previous Acts.

This Act provided for the administration of highways by highway wardens appointed by the Parish Vestries. These wardens either acted merely for the parish for which they were appointed as a separate highway district, or in conjunction with the wardens of other parishes in the case of a Highway Board. In either case the wardens were controlled by the Justices of the Peace for the sessional divisions of the county.

The Act contained 120 clauses, not more than 30 of which have any reference to present-day procedure ; in fact, the Act may be taken as almost obsolete. Subsequent to the passing of this Act, twenty-seven Acts relating to highways have come into force, four of which have reference to motor driven vehicles.

The law of highways is complicated not only by so many Acts, but by the various Orders made thereunder, and is incomplete in not containing provisions to meet present-day requirements. The time has arrived when one Act, embodying the construction, maintenance, and provision for regulations for vehicles using highways should come into force. Such an Act should provide power to deal with the use made of subsoil in the laying in of sewers, gas, water and electricity mains, etc. At present the subsoil beneath the highway belongs to the owners on either side, who have full power to construct cellars beneath the footpaths, which if done would restrict the space for sewers and mains to that beneath the carriageway, where the interference due to sewers and mains should be avoided. The undertaker whose duty it is first to provide one of these works is at liberty so to place it as to interfere materially with the construction of the works to be subsequently undertaken. By a little judicious planning in arranging the positions of the various mains, the space beneath a highway might be utilised to much greater advantage than at present, and considerable saving could be effected both in the cost of such mains and in getting access thereto.

By arranging the position of mains much of the disturbance of the surface that now takes place would be avoided. Thus, in the case of wide roads, service mains should be laid on both sides, preferably close to the fences. When new roads are laid out undertakers invariably postpone laying mains until a certain number of houses have been erected, that is, after the road has been constructed. Had these mains been laid in previous to the road being constructed, the disturbance caused by laying in most, if not all, the mains would be avoided. The highway authority should have some power to restrict the appliances, other than actual mains, placed under a highway, and no rights should prevent the removal of obsolete mains or sewers.

With the introduction of asphalte-bound surfacings the question of making openings in a carriageway becomes most important owing to the brittle nature of the asphalte, which goes to pieces if there is any settlement where a trench has been opened. All trenches should in the writer's opinion be filled in by the Highway Authority.

TRAFFIC.

In order to show the changes that have taken place in the traffic carried by highways the writer gives a synopsis of the fraffic returns taken by Mr. Hewitt Griffin, F.S.S., for *Motor Traction*. Those taken at Putney Bridge on a Sunday in June or July since 1905 show the change in pleasure traction, whilst the returns on week days in Edgware Road and Fleet Street show how ordinary traffic has changed. It is unfortunate that these returns are confined to the day traffic, but they are sufficient to show how rapid has been the change from animal to mechanical propulsion, whilst the total traffic has increased enormously, as will be seen from the following tables :—

PUTNEY BRIDGE ANNUAL TRAFFIC CENSUS.
STATISTICAL SYNOPSIS—ALL SUNDAYS.
Specially prepared by H. Hewitt Griffin, F.S.S., M.J.I.

Class of Vehicle.	6th July, 1913.	30th June, 1912.	2nd July, 1911.	26th June, 1910.	4th July, 1909.	28th June, 1908.	7th July, 1907.	8th July, 1906.	25th June, 1905.
Motor 'Buses..	1,851	1,745	1,529	1,009	640	817	983	805	Nil.
Horse 'Buses..	Nil	10	33	80	819	1,076	1,145	1,222	1,613
Motor Vehicles*	1,736	2,125	1,943	1,423	1,300	1,273	805	600	361
Horse Vehicles†	73	113	225	244	229	474	507	609	715
Motor Vans ..	11	8	5	3	2	Nil	Nil	Nil	Nil
Horse Vans....	45	47	40	50	36	50	88	59	52
Electric Trams	**442**	**340**	**483**	**369**	**412**	**Nil**	**Nil**	**Nil**	**Nil**
Traffic—									
Traction	4,040	4,218	3,960	2,804	2,354	2,090	1,785	1,405	361
Animal	118	170	298	374	1,084	1,600	1,740	1,890	2,380
Cycles—Pedal	2,517	3,875	4,476	3,737	4,252	4,164	4,872	5,009	5,318
Motor	341	347	193	116	103	102	169	124	91
Abstract Totals									
Mechanical ..	**4.381**	**4,565**	**4,153**	**2,920**	**2,457**	**2,192**	**1,954**	**1,529**	**452**
Animal......	**118**	**170**	**298**	**374**	**1,084**	**1,600**	**1,740**	**1,890**	**2,380**
Cycle	**2,517**	**3,875**	**4,476**	**3,737**	**4,252**	**4,164**	**4,872**	**5,009**	**5,318**
Grand Total ..	**7,016**	**8,610**	**8,927**	**7,031**	**7,793**	**7,956**	**8,566**	**8,428**	**8,150**
% Power—									
Human	35.82	45.00	50.14	53.15	54.56	52.34	56.88	59.43	65.25
Mechanical ..	62.50	53.02	46.52	41.53	31.53	27.55	22.81	18.14	5.55
Animal	1.68	1.98	3.34	5.32	13.91	20.11	20.31	22.42	29.20
	100.	100.	100.	100.	100.	100.	100.	100.	100.

*Taxis, Motor Cars, and all Non-trade Motor Vehicles (except 'Buses).
† Private Carriages, Gigs, and Cabs (Non-trade, except 'Buses).
"Horse" includes mules and donkeys.

EDGWARE ROAD TRAFFIC (BOTH WAYS).

9 Hours—9 a.m. to 6 p.m.

Class of Vehicle.	Monday 16th Sept., 1912.	Monday 18th Sept., 1911.	Monday 26th Sept., 1910.	Monday 20th Sept., 1909.	Monday 21st Sept., 1908.	Tuesd'y 24th Sept., 1907.	Thurs., 20th Sept., 1906.
Motor 'Buses	2,333	1,599	1,194	1,140	868	763	441
Horse 'Buses	11	21	43	291	598	752	1,776
Motor Cars	585	459	492	360	284	287	158
Horse Carriages, etc.	259	255	313	293	253	317	—
Motor Taxicabs	1,162	1,131	835	477	269	138	10
Horse Cabs	176	260	399	802	1,177	1,051	—
Motor Trade Vans, etc	240	151	117	102	61	68	23
Horse Trade Vans, etc	2,919	3,246	2,961	3,002	3,090	2,689	2,326
Total Vehicles	**7,685**	**7,122**	**6,354**	**6,467**	**6,600**	**6,065**	**5,942**
% Motor	56.21	46.89	41.52	32.14	22.45	20.71	10.63

FLEET STREET TRAFFIC.

12 Hours each Time, 8 a.m. to 8 p.m.

STATISTICAL SYNOPSIS.

Class of Vehicle.	Wed., 23rd April, 1913.	Tues., 23rd April, 1912.	Wed., 19th April, 1911.	Wed., 20th April, 1910.	Fri., 23rd April, 1909.	Thurs., 23rd April, 1908.	Wed., 23rd April, 1907.
Motor 'Buses	3,518	2,770	2,684	2,606	1,586	1,784	995
Horse 'Buses	Nil	Nil	95	343	1,351	1,444	2,241
Motor Cabs	1,442	1,983	1,616	1,158	659	211	48
Horse Cabs	132	228	391	732	1,443	1,681	1,902
Motor Cars	140	116	107	69	112	45	44
Horse Carriages	212	242	273	214	327	263	259
Motor Vans, etc.	135	104	62	45	30	33	34
Horse Vans, etc.	3,952	4,134	4,335	3,663	3,905	3,679	3,250
Cycles—							
Bicycles..........	1,295	1,637	1,279	1,178	1,194	450	1,254
Carriers	728	512	499	358	305	227	241
Motor	9	13	12	4	5	—	5
Abstract Totals—							
Horse	**4,296**	**4,604**	**5,094**	**4,952**	**7,026**	**6,967**	**7,352**
Motor	**5,244**	**4,999**	**4,481**	**†3,882**	**2,392**	**2,073**	**1,125**
Cycle	**2,023**	**2,149**	**1,778**	**1,536**	**1,499**	**677**	**1,495**
Grand Total ...... (all Traffic)	**11,563**	**11,752**	**11,353**	**10,370**	**10,917**	**9,717**	**9,972**
% of Power—							
Mechanical	**45.35**	**42.54**	**39.47**	**37.43**	**21.91**	**21.33**	**11.29**
Animal	**37.15**	**39.18**	**44.87**	**47.76**	**64.36**	**71.70**	**73.72**
Human	**17.50**	**18.28**	**15.66**	**14.81**	**13.73**	**6.97**	**14.99**
Total	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**

† Motor cycles are included in these figures.

The damaging effect of these classes of traffic varies so that it would be impossible to construct any one crust suitable to all classes, except at a prohibitive cost, and even then the damage wrought by traction engines with barred and studded wheels skidding, and heavy horses with cogged shoes, adds greatly to the cost of maintenance.

The use on highways of barred and studded tyres, cogged shoes, and all sharp metal edges should be prohibited.

When one remembers the damage wrought on water bound macadam by the horse omnibus, it is more than one could have realised a few years since that a motor omnibus with a weight when loaded of 6 tons, could travel at 14 miles an hour on roads merely surfaced, or in many cases surface dressed, without considerable additional damage to that wrought by the horse omnibus, which with horses loaded weighs 4½ tons and rarely exceeds 6 miles an hour.

The table on p. 9 compares the former and present omnibuses, their contributions towards rates, etc.

Excessive damage is done to the surface of highways by the skidding of wheels, which seldom takes place in the case of flexible-tyred wheels, but unfortunately is the method generally adopted for braking metal-tyred wheels when descending a decline. Even when placed in a skid pan, the damage done is far greater than if such wheels were retarded by means of a proper foot brake, which allows wheels to rotate without causing skidding. Take the case of an incline on a road traversed by a majority of iron-bound wheels, and the wear of the surface is much greater on the down side than on the up; whilst on inclines traversed mostly by flexible tyres, the greatest damage takes place on the up side.

The table on p. 10 sets out the various classes of traffic that highways have to carry, and the conditions required by each class.

The use now made of highways by motor omnibuses is apparent. The number of persons carried by horse omnibuses in 1903 was 287,386,471, whilst those carried by motor omnibuses in the year ending March, 1913, was 539,250,000.

The horse omnibus, as a rule, did not traverse country roads to anything like the same extent that the motor omnibus does, but was confined to roads and streets with a more or less perfect surface. Had it been capable of traversing suburban and country roads, as the motor omnibus does to-day, we should have heard more of the damage done by it.

A properly constructed macadam road can, at small cost, be surface dressed so as to render it immune from damage by motor vehicles with flexible tyres, so long as the road is not affected by wet, but as soon as the impervious surface is broken

	No. licensed in London 1912.	WEIGHT IN TONS.		Total width of tyres.	Tons per inch of tyre when loaded.	Persons carried.	Hours worked per day.	Speed in miles per hour.	Maximum carrying capacity per passenger, per mile, per 'bus, per annum.	Working 300 days per annum.		
		Empty bus.	Loaded							Cost involved in street scavenging.	Payment in various taxes	Comparative benefit or loss to taxpayer.
				inches							per omnibus.	
Motor omnibus ..	1,962	3.5	6	15	0·40	36	18	7.1	1,303,560	negligible.	£7 13s. 0d. on petrol £37 10s. 0d.	Benefit £45
Horse omnibus ..	90	1.3	4.5 (includ'g horses)	8	0·56	28	14½	5.9	667,290	at 1s. per day £15 per annum.	£3 5s. 0d.	Loss £11 15s. 0d.

Cognisance is not taken of damage done to highways which varies with the class of pavement.

METAL TYRES AND SHOES.

Form of Traffic.	Way in which damage is effected.	Road surfaces best suited to withstand damage.	Estimated cost per yard sup.	Effect on road surface and rolling stock.
Light and specially heavy loads so carried.	Surface subjected to the rolling action of metallic tyres under more or less weight causes grinding action specially destructive to water-bound macadam.	Asphalte bound macadam or wood.	5s. to 12s.	The effect on the pavement and rolling stock is much greater than where flexible tyres are used.
Braking of wheels by skidding either locking wheels or placing same on pans.	A sliding action causes great destruction to the road surface, especially when the surface is displaced by the wheel or pan sinking therein.	Well dressed, compact stone, in lengths of at least 1ft. 6in. laid on concrete offers most resistance to this form of damage.	15s.	Very damaging to road surfaces and rolling stock.
Traction engine with barred or studded wheels	Crushing, displacing and grinding the road surface.	The last mentioned paving.	15s.	This is one of the most destructive forms of traffic a road has to withstand.
Horses shod with metal shoes.	Pounding action injurious in the case of weak surfaces and tar dressings, especially where sharp cogs are used.	As above.	15s.	Solid stone surfaces cause horses feet and legs to fail before they would otherwise.
Edges of metal coming in contact with road surfaces.	Exert a cutting action thereby injuring the surface.	Stone sett pavements offer most resistance to this cutting action.	11s.	

SELF PROPELLED VEHICLES WITH FLEXIBLE TYRES.

Form of Traffic.	Way in which damage is effected.	Road surfaces best suited to withstand damage effected.	Estimated cost per yard sup.	Effect on road surface and rolling stock.
With flexible tyres and loads not exceeding 5 tons.	When the action of the surface binder is destroyed, as when water bound macadam becomes too wet or too dry, the road surface is rapidly destroyed by this form of traffic.	Asphalte or bituminous bound surfaces.	4s. to 7s.	Provided the road crust is sufficient and well surfaced, enormous quantities of this traffic can be carried with little wear of road and rolling stock and little exertion of power.
Flexible tyres and heavy loads : motor 'buses for example.	Excessive tendency to displace material forming crust due to weight and speed.	Stone setts or wood blocks on 9in. of concrete, or at least 2in. of asphalte bound surface on ample crust.	9s. 6d. to 13s. 6d.	During dry weather a less expensive road will carry this traffic.

The damage done to flexible tyres by loose stones or shingle is excessive.

up, as it is by excessive wet or frost, the road is rapidly damaged where this traffic is excessive, and especially where the road has to carry motor omnibuses. The damaging effect of this latter form of traffic, so far as we can see at present, has resulted in the destruction of Portland cement concrete 6in. thick, where placed beneath wood paving and asphalte. The author has only found one exception in the London districts, viz.: that of George Street and High Street, Richmond, which carries no fewer than 1,155 omnibuses per day of 16 hours, and 1,878 on Sundays, equivalent to 55,212 tons per week, on a carriageway 25ft. 0in. in width, the carriageway being paved with 5in. creosoted deal blocks, laid on 6in. Portland cement concrete. The only reason the author can adduce for this paving withstanding such a heavy traffic is that it is on a gravel subsoil. In other districts the thickness of concrete has been increased to 9in., and where trenches are subsequently made, 12in. is laid, as a rule, beneath the blocks used in repairing the surface.

The excessive damage caused by motor omnibuses and vehicles taking heavy loads at high speeds is due to the impact with which the wheels carrying such loads strike depressions in the road surface and as it were, knock the bottom out of such depressions, thereby forming hollows. The impact increases with the depth of the hollows, and as water settles in these hollows, the road crust goes rapidly to pieces. The impact causing these hollows might to a great measure be avoided if such traffic were carried on three axles instead of two, as at present. A good example of what might be expected by the adoption of this principle may be seen from the roads rolled by a 3-axle roller, which produces a much more even surface than the ordinary 2-axle roller.

Reference to traffic would be incomplete if mention were not made to the allocation of part of the highway for a tramway track, which should never have been allowed, on 2,600 miles of highways in the United Kingdom. The amount invested in such undertakings by Local Authorities is some 42 millions. Where such tracks are laid, they form most serious obstructions to traffic, and are a fruitful source of accidents, whilst it is impossible to maintain a properly surfaced road beside these tracks. As tramcars are confined to the track, they form a serious obstruction to traffic, especially when a car is disabled, which usually results in a large number of cars being stopped. The motor omnibus, on the other hand, is free to use any part of the highway, and offers greater facilities to take up and set down passengers, whilst it can avoid traffic, which would be impossible for a tramcar to do.

Conditions Required to carry Traffic.

The failure of our roads to carry the traffic of to-day is due in great measure to neglect of the principles laid down in the 18th century by Telford and Macadam. Telford insisted on a foundation of large stones placed in position by hand, which is the kind of foundation required to carry the motor 'bus and heavy traffic of to-day. Macadam insisted on a crust formed of evenly sized angular stones keyed together without binding material. Specification No. 7 issued in July last by Road Board fully bears out Macadam's principles. By waterproofing the surface and so preventing water penetrating to the subsoil, the power of such subsoil to carry weights transmitted by the road crust is very materially increased. It would appear from this that in constructing a road the depth of crust may be reduced, but it is not wise to do so, as the traffic now carried is far in excess of that which an ordinary road crust was constructed to bear; this is borne out by the effect of motor 'buses in destroying the 6in. of concrete which was considered sufficient to carry all previous forms of traffic.

For rapid traffic it is essential that the road surface should be as smooth as possible. Pitched crossings and pitching round manholes should be removed, and as few manholes and surface boxes as possible should exist in the carriageway.

When stones of various sizes are used the large stones invariably work to the surface, and will destroy the effect of any surface dressing so far as it is intended to render the surface impervious. In addition to the tendency of the large stones to work to the surface such large stones predominate in certain parts of the layer, and there is no means of insuring a uniform mixture of the various sized materials.

In the various books and papers that deal with road crusts the writer has failed to find any reference to the force that appears to him most destructive. Such works deal with the road crust as the conveyor to the ground beneath of weights that come on to its surface, and the depression caused thereby, but no mention is made of the force of upheaval that acts contiguously to the area of depression; in fact, we have been considering road crusts in a somewhat similar manner to the voussoir of an arch, which conveys the weight carried by the bridge to the abutments and thence to the foundations. If such an arch had to withstand forces from beneath, it would be necessary to introduce tension rods on the extrados to counteract such forces. The force causing the upheaval which takes place in the case of a road crust acts in an exactly similar manner to that of a force introduced beneath an arch, and should be resisted by surfacing material having as great a tensile strength as it is possible to obtain with economy, such as would be afforded by a tough bituminous coating. No better method could be devised to destroy such tensile strength than by introducing large stones into such a coating, and as it is essential that the coating should be as homogeneous as possible, the introduction of various sizes of stone is most deleterious. In such a surface coating there are several forces set up by the wave-like action that takes place, which act in a variety of ways, and it is essential, in order to prevent destruction from these combined forces, that the surface coating should be as homogeneous as possible, and at the same time tough and resilient. The writer feels certain that if these conditions had been complied with, the failures that have resulted throughout the country from the use of asphalte surfacings would not have occurred. He has seen these surfacings laid with good materials and in a manner with which no fault could be found other than that various sizes of inelastic material have been introduced. On the other hand, in the case of surfacings in which only ⅜in. granite chippings have been used, by far the best results have been obtained.

Naturally, the deeper the road crust the less wavelike action, and it is due to the small wavelike action that takes place on dry, sandy subsoils that thin road crusts have carried such weights, as may be seen at the present moment in New Eltham, where the excessive traffic on the Sidcup Road has been carried by a road crust less than a foot in depth. The same occurred on Wimbledon Hill, before the widening took place in 1892, the road crust being under 4in. in depth.

The writer has observed many of the roads covered with a thin layer, say 1in. to 1½in., of tarred granite, which, at a slightly greater cost than that of repairing the waterbound surface, has rendered the road impervious, and so far as can be seen, immune from the effect of weather, so that it is able to carry much greater traffic, and in many cases a small amount of motor 'bus traffic. It is recommended that this material should be laid on the surface of an ordinary macadam road, which, if possible should not be disturbed by scoring.

Surface Dressings.—These dressings are the only means of providing a road suitable for modern traffic without a large capital outlay, and where the traffic is sufficient and not too severe their adoption may not increase the cost of maintenance. In London districts where the removal of street detritus is so costly, surface dressings may effect a saving. Such dressings cost about £50 a mile, a figure which is prohibitive in the case of many country roads.

To get the full benefit of any dressing containing tar and pitch, the sun's rays must have access to such dressings, and all depressions in the surface should be filled in so as to prevent water lodging. These dressings have done much towards reducing the dust nuisance ; in fact, in districts where all the roads are dressed, dust and the necessity for the water cart are almost obviated. With a well kept camber, rain runs off as it falls, so that mud seldom forms.

The dressing generally used by the writer is gas tar containing not more than 5 per cent. of water to which pitch in the proportion of a pound to 3¾ gallons of tar is added, heated to 160 to 180 degrees F., discharged direct from the boiler on a well swept road surface and worked in with rubber squeegees, and then covered with ⅜-in. Guernsey granite chippings rolled in.

The cost per square yard is 1.46d. made up as follows :

Labour in sweeping clean and spreading	0.28
For tar and pitch	0.59
For granite chippings	0.39
For rolling	0.04
For carting and hire	0.16
	1.46d.

When dressed once a year this dressing stands fairly well on roads with small traffic. A second dressing adds greatly to its endurance and power to resist traffic. Much better results have been obtained with Tarvia at a total cost of 1.84d. per yard sup. Sections taken from roads that have been repeatedly dressed once a year show that the material used (generally tar) has penetrated to a considerable depth. It is, however, unfortunate that even after years of dressing the surface will not remain watertight in continued wet weather when subjected to heavy traffic. During fine, warm weather repairs can be effected in surface dressed roads ; in wet weather, however, such repairs are next to impossible.

Surface dressing will no doubt be superseded so soon as a reliable surfacing material at a reasonable price is placed on the market ; such material should admit of its surface being patched, without having to resort to scarifying. The writer has seen an asphalte bound macadam, which when laid between kerbs has stood well, show signs of approaching failure where laid without the lateral support that kerbs afford.

So far the trials in surface materials have shown how unreliable are the materials now on the market to withstand mixed traffic in various weathers. To a great extent this is due to our expecting to get a surfacing material for 4s. or 5s. a yard super to carry traffic that requires a pitched paving costing three times that amount.

The writer considers it misleading to criticise any one pavement tried say on the Kent trials. Firms may have a material that, in the hands of a Highway Surveyor and his staff, would produce a good road, but is an utter failure laid by a scratch gang under the superintendence of a man whose training has in no way fitted him to undertake such work.

The writer is of opinion that the surface of the future, except for very heavy traffic, will be composed of hard stone granite or basalt of uniform gauge, not exceeding $\frac{3}{4}$in., held by bituminous binder, and laid in thicknesses varying with the traffic to be carried, and where possible on the existing road surface without resource to scarifying. The breaking up of any of the existing crust, by scarifying or scoring, materially reduces the carrying power of the crust, which it is essential to preserve in the case of thin crusts.

For heavy traffic, there is no doubt that whatever surface paving is used, it should be laid on Portland cement concrete.

State of Highways in Relation to Economic Conditions.

It is to be regretted that so few statistics are to hand bearing on this subject. Their want, however, is to a great measure supplied by the great increase in road borne goods and passengers in recent years.

Any reduction in the cost of haulage must bear an intimate relation to the cost of production, as not only has the material to produce an article to be hauled but the article itself has to travel. Those engaged in producing the article in most cases travel to their work, whilst the food and clothing of most artisans is conveyed to them by road.

The following table taken from the reports of the London Traffic Branch of the Board of Trade shows that the number of passengers carried by omnibuses has increased 344 per cent. between 1886 and 1911. During the period under consideration the population of Greater London increased only 40 per cent.

Number of Passengers Carried by Omnibuses.

Year.	Passengers.	Estimated population of Greater London.	Journeys per head in Buses.
1886	90,708,966	5,182,130	17.5
1891	158,926,250	5,633,806	28.2
1901	269,933,759	6,581,372	41
1909	311,000,000	7,112,145	43.9
1910	377,207,555	7,181,415	52.5
1911	400,628,487	7,251,358	55.2

Much has been said as to the cost of maintaining highways in such a condition as to carry motor traffic. The actual cost of maintaining the various classes of roads throughout the country is given in the Local Government Board's report for the year 1910-1911, during which period the following amounts were expended by Rural District Councils:—

	Maintenance.	*Improvements.*
Main Roads	476,333	16,599
Other Roads ..	2,174,914	59,359
	£2,651,247	£75,958

giving a total expenditure of £2,727,205, of which £75,958, or 2.8 per cent., was spent on improvements.

Costs of maintenance per mile given on page 193 of the Local Government's report for 1910 and 1911 :—

			Cost of Maintenance per mile for the year ending 31st March.		
		Maintained by.	Year 1905.	Year 1909.	
			£	£	
Main Roads.	London and County Boroughs not included.	County Councils ..	72	80	Increased cost £2 15s. 0d. per mile.
		Borough ,, ..	207	222	
		Urban ,, ..	201	198	
		Rural ,, ..	63	72	
Other Roads.		Borough Councils ..	105	108	
		Urban ,, ..	80	79	
		Rural ,, ..	22	23	
		County Boroughs ..	146	136	
		Metropolitan Boroughs	381	325	Decrease in cost £56 per mile
		Corporation of London	1,087	774	£313 per mile

These figures show that so far the introduction of motor traffic has not materially increased the cost of highway maintenance, whilst in the well paved streets of the City of London the cost has decreased 29 per cent.

It is impossible to estimate the benefit the public derives from improved facilities of transit ; perhaps the statistics which throw most light on the subject could be derived from a comparison of the accumulation of capital previous and subsequent to the introduction of railways.

Sir J. Wolfe Barry, Past-President Inst.C.E., and Mr. R. C. H. Davison, M.I.C.E., have in a Report to the Advisory Board of the Royal Commissioners on London Traffic, 1905, endeavoured to estimate the loss caused to inhabitants by want of proper travelling facilities. They give the number of persons leaving their houses daily for work in Greater London at 2,120,708. Of those who enter the Central Area daily :—

Railways carry	719,933
Tramways carry	145,540
Omnibuses carry..	151,007
	1,016,480

The amount earned annually by all classes is estimated ..	£173,291,000
The cost per annum of road vehicles including tramways carrying passengers ..	16,562,400
	£189,853,400

1 per cent. on this sum is £1,898,534.

If ¼ hour be lost out of a working day of 8 hours, it means a loss of £5,695,602 per annum, without any allowance for the loss incurred in the delay in transporting goods.

The Laying out and Improvement of Highways.

In the provisions suggested by the Local Government Board for adoption by Local Authorities in the bylaws for the regulating the laying out of streets, such important points as (*a*) the angle at which roads join, (*b*) rounding off corners, (*c*) the question of a maximum angle of inclination, are not dealt with, whilst the total width provided for a street is 36ft.; in fact, so meagre are the powers of Local Authorities, that except in the case of special Acts, no power exists to prevent the laying out and construction of highways quite unsuited for modern traffic. Were it not for the fact that those developing estates desire to keep on good terms with the Local Authorities, roads might be laid out at variance with all the desiderata for modern traffic.

This shows still further the necessity for new legislation in respect of highways.

The considerations that should govern the laying out of new roads are—(1) That where a road is likely to become a means of communication between centres of population, the facilities for such communication should be studied and adopted to the fullest extent practicable. (2) That all facilities for modern traffic, such as wide roads and rounding off corners should be afforded. (3) The question of carrying off rainfall in excess of that for which the sewers have been designed, has to be considered, as in most cases the only available means other than the sewers are the roads. Thus roads crossing valleys are to be avoided, whilst roads contouring, or better still with a slight inclination up a valley, are to be encouraged. By so laying out roads the natural character of a valley is maintained as far as can be.

The cost of ultimate maintenance of proposed roads should be carefully considered. In most cases there is too great a tendency to create as many building plots as possible, thereby increasing the length of roads and the ultimate cost of maintenance.

Roads provide an unobstructed passage for air between the fronts of houses, and in the past houses have been so placed that the space between the backs afford a secondary passage for air almost as important as that between the fronts.

Sewers and mains of all description should be laid in where possible before the road crust is formed. When owners develop their own estates much of the preliminary work, such as house connections, can be got in before the road crust is formed.

The writer strongly advocates each estate being dealt with as a whole, that is to say, the estate owner having the houses built instead of selling off plots.

In planning the position of proposed roads the amenities of the district should be considered so that the view of objects of interest should be interfered with as little as possible.

Good trees should be preserved where possible and in populous districts spaces for flower borders and seats are necessities.

The writer does not advocate the completion of the road crust before houses are built, but that the preliminary works should consist of laying out and forming the road and placing a 12in. by 8in. granite flat kerb on either side of the carriageway, and the placing in of sufficient foundation for both carriageway and paths. When buildings are nearing completion the kerb should be set on concrete and the crust for carriageway and paths completed.

The writer is a strong advocate of carrying out all necessary improvements at as early a date as possible, as in his experience delay means additional expense.

Discussion.

The **President** proposed a vote of thanks to the author, who, he said, seemed to think that the present law, with regard to statutory companies who had to lay mains in a public road, needed alteration, and that the property of the adjoining owners in the subsoil ought to be taken away and to belong to the road authority. That seemed to be a common sense opinion, but the fact remained that the property in the subsoil had never been taken over or bought by the State, and had always remained the property of the original owners of the adjoining land on either side, and there would be a great deal of difficulty in getting it conveyed to the road authority without compensation. Though the value of such land to the present owner might be small, still, when anybody wanted to buy it the price would go up enormously.

Again, the suggestion of the author that the local authority should have power to prescribe where mains should be laid looked a very sensible one, and one which ought to be adopted; but it must be remembered that the local authority could not be depended upon to act impartially between all the different interests in the road. For instance, if the gasworks were owned by the local authority and the electrical supply was owned by a public company, it could not be expected that the local authority would behave impartially as between its own right to lay the gas mains and the right of a public company to lay electric cables.

He quite agreed with Mr. Cooper's suggestion that the mains should be laid in the footway. The author desired that the mains should be put into a road when the road was being laid out. He (the President) knew a district in which many miles of roads had been laid out for ten years, and, as yet, only about 1 per cent. of the houses had been built. Would any public company lay mains and wait so long before getting return for their money?

As to Mr. Cooper's desire that there should be a central authority for the roads, perhaps many in the meeting would be disposed to agree with it, but there were certain definite difficulties in the way of the establishment of such a body, and there were some very definite advantages in having local control, that is to say, control by the authority which raised the money. If the authority which spent the money had also to raise it, more care would be exercised over its expenditure. The difficulty might be got over probably by a system of grants in aid from a central authority, instead of all power being taken away from the local body and put into the hands of a central one.

He had constantly heard it said that the roads abroad, and particularly in France, were examples of what roads should be; but he did not know any roads which on the whole were better than the roads in England at the present time. He believed that a great many who talked about the wonderful roads in France did not really know what the ordinary roads in that country were. They might know one or two military roads, but not the ordinary roads. Considering that the whole of the traffic of England had been revolutionised within a very short time it was somewhat remarkable that the road authorities had done as well as they had. Let Kent be taken as an instance. If all the roads in the country were up to the standard of the roads in Kent there would not be much to grumble at.

There was one other point with regard to a central authority. Mr. Cooper himself mentioned it, and he objected very strongly to the total width provided for a street being 36ft. Well, the Local Government Board was a central authority, and efficiency evidently depended not upon whether there was a central authority or a local authority, but upon what the particular authority happens to be. He thought that, instead of taking all the power out of the hands of the local authorities and putting it into the hands of a central authority, it would be better to have a central authority with limited control, but with power to give grants in aid.

The Secretary read the following communications.

Mr. Wallace E. Riche, Secretary of the Roads Improvement Association, wrote :—

" I should like specially to support Mr. Cooper's views concerning the need for a central body to be established to handle certain road matters. This has long been advocated by this Association. In particular, I would like to endorse his suggestion that such a central body should represent not only the highway authorities, but also the users of the highways.

" It must be borne in mind that the users of the roads ' pay the piper ' ; they pay the rates and also contribute the duties that make up the Imperial Road Improvement Fund. Upon this score alone it would seem only fair that they should have some share in ' calling the tune.' Other considerations are that road users know what they want. It must be of assistance to our highway authorities and their officers to know what is expected of them and what the particular needs of traffic are. Such close co-operation would enable road users to appreciate more intimately the difficulties under which our highway authorities have to carry out their onerous duties.

" I would also like to support Mr. Cooper's demand for a new Act to govern highway matters. The existing law is undoubtedly cumbersome and expensive. A new consolidation Act (which should deal specially with the points Mr. Cooper suggests on p. 175 of his paper) would undoubtedly assist towards a cheaper and more efficient administration of the highways.

" The damaging effect of projections, fitted in tyres and horses' shoes, upon road surfaces has long been realised by this Association, and I am glad to see this point is emphasised by the author. As representative road users this Association has been doing what it can to remedy this evil, and I would like to draw your attention to the Horse Shoe Competition that is now being conducted by this Association with the idea of producing a new, or improved, type of horseshoe that will give horses a more satisfactory foothold upon the modern smooth road surfaces, and at the same time minimise the damage now caused to such surface by the calkins and other projections frequently fitted in horse shoes.

"If road engineers would co-operate in giving publicity to this competition, the Association would be greatly assisted."

Mr. G. W. Willcocks wrote :—

"There are one or two points to which I would draw attention, viz. :—

(1) The proper laying out of a road (plan and section), which can only be done by a man who knows the proper use of field instruments and has an eye for country.

(2) The amount of camber, which should vary with the longitudinal gradient of the road and the rainfall.

(3) The depth of the crust, which might vary with the nature of the natural ground.

(4) The surface of the carriageway, which, if too smooth, is dangerous for horsemen, and is liable to produce side-slipping in motor cars during the winter, while it affords no proper foothold for draught horses at any time. The question of horses will affect cavalry and artillery, so the military authorities may have something to say about this question in the future.

"I read a paper on 'Roads and Road-Ways' before the Civil and Mechanical Engineers' Society in 1879. There have been many improvements since then, but I think the old principles still stand."

Mr. E. Van Putten said that he quite agreed with Mr. Cooper's plea for a central authority. Such an authority would not be constituted to carry out the actual maintenance of the roads, but would be constituted in some way like the London County Council, which had a certain authority over the whole of the highways of London, as the Local Government Board had over the highways of the country. The unfortunate point about the London County Council and the Local Government Board, so far as their jurisdiction over roads was concerned, was that their duties were so manifold that they could not pay sufficient attention to roads. He thought that the roads of this country deserved an authority which had nothing else to do but look after them. The 36ft. road sanctioned by the Local Government Board, and to which Mr. Cooper referred, was simply absurd. In London a 40ft. road was insisted on by the London County Council for carriage traffic, and that was a great deal too narrow. Fifty feet should be the minimum in London and the country for carriage traffic roads.

As to forecourts, he thought that a certain portion of them should be given up where they were necessary for the widening of the roads, and the buildings should not be allowed to come beyond a certain building line. In London this matter was arranged by the Superintendent Architect of the London County Council, and good results were obtained all round. He did not know whether this was the case outside the London area.

No reference had been made to the action set up by the twin-tyred vehicles. The twin-tyre was pressed down and sucked out the whole of the binding material of the road ; even if it were a granite paved road it sucked out the joints, and produced corrugations in a tar macadam road. He thought that this was the most destructive thing on the roads at the present time, and even worse than a traction engine.

He was very much astonished at Mr. Cooper's remarks on page 182 about the tramways. Both he and Mr. Cooper had to look after highways, and were responsible for the expenditure. The Borough Engineer was always blamed if the rates went up, and therefore he was surprised to find Mr. Cooper saying that tramways should never have been allowed on 2,600 miles of highways in the United Kingdom. In his (Mr. Van Putten's) borough the tramways had been more or less a blessing to him. They had maintained the 17ft. down the middle of the road. When they were laying the electric trams in his borough he was under the impression that the tramway traffic would be so great down the middle of the road that nothing would go on it, and he should not get any benefit from the fact that the 17ft. in the middle of the road was maintained by the London County Council, but he must say that his experience had shown that he was entirely wrong, for nearly the whole of the traffic went upon the tram lines. It was constantly driven off to make way for the cars, but, for some unaccountable reason, it came back again directly a tramcar had passed, and the wear on the rest of the road was very much less than otherwise it would be.

With regard to the finding of the money, he thought that all mechanically propelled vehicles should be taxed more heavily than they were at the present time. The petrol tax produced about £40 per omnibus per annum, and that sum went to the Road Board, and he thought that all the local authorities found it exceedingly difficult to get any money out of the Road Board. The Road Board kept the money for an emergency, and they gave out a certain amount, but the petrol tax, as far as he knew, must be earned chiefly in London and the surrounding districts, such as Wimbledon, Kingston, &c., but the London authorities did not get their proper proportion of it. He certainly thought that a larger proportion of the maintenance of the highways should now be borne out of an Imperial fund, but how that was to be created he did not know unless it was by putting a bigger tax on motor vehicles.

He did not think that the breaking of the concrete to which Mr. Cooper had referred was caused by the motor omnibuses and vehicles of that description so much as by motor vehicles over 3½ tons in weight shod with steel tyres. Vehicles of one of those classes were allowed to travel at eight miles an hour, and the other class was limited to five miles an hour, but these speeds were too high for vehicles of such weights, and vehicles travelling at such speeds had the effect of hammering upon roads more than the twin tyres of the motor omnibuses or any other rubber-tyred vehicle.

In London the authorities had a certain amount of jurisdiction over gas mains, water mains, and electric light mains. In one case the recommendation which he had made to his council was rejected by one of the companies, and they appealed to the Board of Trade. The Board of Trade decided against them, and his local authority got their recommendation carried out. It was that the mains should be laid on the footway and not on the roadway. The object of this was to prevent the road from being broken up.

Mr. J. S. Killick said that he would like Mr. Cooper to give a definition of what he called a bituminous surface and an asphalted surface respectively, because in the paper there was some confusion on this point.

Unnecessary width of carriageway was purely a waste. All that was required was sufficient width to carry the traffic. He was speaking particularly about country roads. In one of the home counties quite recently some statistics of traffic were taken on an 18ft. road. A width of 8ft. was marked out in the centre, and it was found that 80 per cent. of the total traffic passing over the road passed either wholly within that width or partly within it. On a 24ft. road the central 8ft. space was marked and 70 per cent. of the whole of the traffic passed within or partly within it. That seemed to show that the additional width between 18ft. and 24ft. was an unnecessary burden on the ratepayers in regard to maintenance.

Mr. Cooper in speaking of asphalted or bituminous surfaces, said that the material should be of uniform size, and that he thought that material of various sizes tended to break up the road, as the large stones worked to the surface. He (Mr. Killick) thought that that was incorrect, and that stones of various gauges and of reasonable size tended to make the roads voidless, and, as the voids in a road were decreased, so the possibility of water getting into the road decreased, and, consequently, the life of the road increased.

Mr. E. B. B. Newton said that, with regard to the widening of streets by the transference of forecourts to the highways, he thought that Mr. Cooper, more in his remarks perhaps than in his paper, leaned too far in the direction of something approaching confiscation. Everyone agreed that a seller was entitled to a fair price from a buyer. The difficulty was in settling what was the fair value in the case of land taken for the public benefit. Of course, everybody liked to see improvements carried out at a minimum cost to the ratepayers or taxpayers, but the effect on individuals had to be considered, and the tendency in England always had been to insure that the individual who was often to an extent helpless should not suffer hurt from a big corporation. That such a principle was a pretty sound guide for local authorities would be accepted by the man in the street.

He thought that there was a great deal to be said in favour of a central authority, and that most engineers would agree. The Road Board was only at the beginning ; he hoped for the future.

With regard to the laying of mains, it had been in his mind always that road authorities in London, at any rate, had larger powers than the paper suggested. " Undertakers " had been required on many occasions within his experience not only to lay mains in the footway instead of the carriageway, but to lay mains along both footways rather than in one only. This was in order that the carriageway should not be disturbed by the laying of services across it. The " undertakers " had done it without demur, in a number of cases often with advantage not only to the local authorities but to themselves. One of the great difficulties of metropolitan engineers in keeping up their road surfaces was that of trenches, and " undertakers " were also averse from openings because the expense of breaking up and reinstating involved was very great. He did not think that " undertakers " were any more anxious to break up roads than the road authorities were. The reinstatement of trenches needed to be done in a thoroughly efficient manner. The adequate reinstatement of concrete foundations was so difficult that he had often considered the question of the advisability of reinforcing such foundations, and doubtless many other engineers had done the same. But reinforcement itself would create further difficulty in connection with the opening and proper reinstatement of roads.

He thought that Mr. Cooper, in referring to the weights of vehicles should have combined a mention of speed, which was a most important factor. When the motor car regulations came in some years ago the questions of their effect on roads was taken up in London by the local authorities, and the difficulty which would be caused by the increased weights and speeds, etc., was then pointed out clearly to the Commission then sitting, by a committee of engineers representing the conference of metropolitan boroughs.

With regard to George Street and High Street, Richmond, he did not quite agree that what the author had described as due to the particular material composing the subsoil. Truly, however, gravel was the one subsoil to be expected in the neighbourhood of London that was most likely to form a good subsoil. The reason that the concrete only 6in. thick had stood was because there was under it a good sound subsoil. He could give Mr. Cooper other similar instances, but where there was no gravel. Heavy traffic crushed shallow concrete foundations by reason principally of the subsoil under the concrete giving way.

With regard to bituminous macadam, he did not think that there was at present known any material that was capable of being used successfully on a road where there was traffic equal to that of heavy fast motor omnibuses.

As to the use of macadam composed of material of uniform or of varying size, he personally had found good results from roads where material of mixed gauges had been laid, and equally he had obtained good results from roads where the material of each layer, but not all the material, was of the same gauge.

One of the best known contracting firms, when required to undertake a period of maintenance for such a carriageway, insisted on being allowed to use mixed gauges, and that, he thought, spoke for itself. They all knew that in the mixing of concrete the modern theory was that the sizes of the material should be so proportioned in the mass that the interstices should be as nearly as possible done away with. The use of mixed gauges in macadam went in that direction.

Everyone who had practical experience would agree that the skill of the men laying the material was of the utmost importance.

In the metropolis the amount of material worn off the roads, or at any rate the débris removed from them, had decreased extraordinarily since the advent of the motor traffic.

Mr. R. W. A. Brewer said that one of the most interesting points which had come to light in the paper would be rather a surprise to most people who followed the road question in a superficial way, and that was the decrease in the cost of road maintenance. This was most noticeable in cities, and in the country the increase was only very slight.

A very remarkable difference of opinion had existed for some years past between various people connected with the making and using of roads, and it was a great pleasure to him to notice how very much more friendly they all seemed to be this evening than they had been in the past, particularly in connection with tramway undertakings. He remembered several occasions when in that Society heated arguments had taken place between road-makers and road-users; but now they all seemed very pleased that the advent of the motor vehicles had brought down the cost of road maintenance in certain places rather than increased it.

When motor cars first came on the roads there was a very bad time to go through, particularly at the hands of the taxpayers, who said that the roads were being ruined, and that the cost of road maintenance was going up so enormously that motor cars would have to be taxed off the face of the earth. The motor car contributed very considerably towards road maintenance.

He should like to know where the author got the figures which appeared on p. 174, and which referred to certain allocations of moneys. In the third report of the Road Board there was a figure dealing with motor spirit duties in 1912-13. The second item was £702,000 odd, as against £500,000 given in the paper, and the licence duties were practically half a million, as against £358,000. Some of that money, he took it, was put aside for road improvement.

Before he left the question of the contribution of motor vehicles towards road taxation there were other figures upon which he would like a little further explanation. He did not quite know what "other Imperial taxes" meant. He would like to compare the figure of £15,000,000 given in the paper with the figure for 1911 for expenditure upon roads outside London County boroughs, which was £6,700,000 odd. It would seem that the roads outside London were taking something under £7,000,000, and the large figure of 83¾ per cent. to be found out of local rates did not give a true indication of the burden on the local taxpayers.

With regard to the dweller in the country, his increase in road maintenance had only amounted to a little over £2 a mile, and when his roads were improved the maintenance cost would go down quite noticeably.

With regard to the Road Board, the Automobile Association made a very strong protest at its annual meeting to the Road Board with regard to what it was doing with its two and a half million pounds in hand, a sum which was, of course, increasing every year. They said that it was allocated, and so on, but it was invested in funds. He supposed that they were waiting for Indian Stock to go up and make their investments more valuable.

Mr. Max Clarke said that he did not profess to be an engineer, but he had had the misfortune to be chairman of the Works Committee of the Borough of Holborn for two years. He had figures which he hoped would controvert the remarks that had been made as to the saving of money in consequence of the advent of the motor omnibus. He understood from the paper that the decrease in cost was about £56 a mile in the Metropolitan Boroughs and £313 a mile in the City. In New Oxford Street (See p. 200) the Borough of Holborn had spent £29,379 in thirty-five years. His information commenced with 1878, when they paid 1s. a yard per annum for maintenance. At the present time they were paying 3s. 8½d., and he thought that very shortly they would pay 4s. They relaid a portion of Oxford Street in 1909 with 2in. asphalte which cost £5,413. A portion of this asphalte, which was laid in 1909 just opposite Meux's Brewery, had practically disappeared, and the road had been relaid with granite setts very artistically put together. This was the most expensive paving that had ever been done in the Borough.

It was difficult to understand whether the paper took in the whole of the United Kingdom or whether it was a synopsis of suburban and City roads. His own experience was absolutely confined to a main arterial road in London.

From the paper it would appear that London was spending less on roads than formerly, but the reverse was the fact. His Borough Council paved a place which he called " Tottenham Circus "—the junction of Tottenham Court Road and New Oxford Street—in 1911, with granite setts which were fairly well laid and fairly smooth on the surface. They had not spent another penny on that work. It was laid partly with 12in. of concrete, and was about 2ft. 6in. thick on the average. They found that at Tottenham Circus, just before it was repaved in 1911, the pavement subsided about 6in. over an area of about 3 yards square. The road was shut up, and the area was examined. He was present, and took a considerable amount of interest in the matter. The Tube station was underneath the greater part of the paving in question, and it was found that when the station was built certain poling boards had been put in to keep up the earth, and the top surface of the station was finished about 7in. short of the poling boards, and those boards and the concrete had been supporting the surface in Tottenham Circus for about ten years. The investigations went further, and a piece of road to the east was opened, when precisely the same state of things was found, but the road had not fallen down. There was a space between the boards and the top of the concrete at the station, and a pole 5ft. or 6ft. long could be put in and moved about. but the paving was sound. Holborn had been very much abused by many people for advocating a return to granite, but the granite had not cost sixpence since it was laid. He had figures for High Holborn (See p. 201) from 1879 to the year 1910. They paid 1s. originally. From 1904 to 1910 they paid 2s., and they had spent on that portion of the street from 1879 to 1910, a length of 379 yards, £20,199. With regard to 522 yards in High Holborn (See p. 202) his information commenced in 1886, when it was paved with 2 in. of asphalte on 6 in. of concrete, costing £4,127, and the maintenance at 1s. a yard from 1888 to 1903 had cost £5,237. They had a little difficulty in this part of High Holborn through the breakdown of a sewer that had been put in by another authority. They attributed the whole of the sinking to the sewer and the timbering, in consequence of which they were put to gigantic expense. In September of last year the portion of the road between the Council's office and Kingsway was relaid at a cost of £3,114. That was, roughly, about 14s. 4d. a yard for the setts, and the job was not very satisfactory. It was not nearly so good as the work which had been done in " Tottenham Circus," and it was not to be compared with what had been put in front of Meux's Brewery, which had cost about 30s. a yard. He would like to dispose of the idea that, in central London, at any rate, the introduction of the motor omnibus had reduced the outlay for repairs.

With regard to a central authority, it was a most glorious thing to talk about, but what would the ratepayers say of a central authority like the Water Board, for which a large contribution had been asked lately to make ends meet ? The old water companies paid considerable dividends. In olden days it was decided that the street made under Act of Parliament from Paddington to the " Angel " Tavern was to have forecourts of a depth of 50ft. Who allowed those forecourts to be built upon ? It appeared to him that when an Act of Parliament said that a road should be of a certain width and have forecourts of a certain size, it should not be competent for any authority to decrease the dimensions. If they had egregious failings on the part of such bodies, might they not have equal failings in the case of an authority that was set up for the purpose of dealing with roads ? He should very much object to a central authority coming to Holborn and saying what was to be done there. He did not think that the central authority would pay the slightest regard to local opinion.

Did the reference to widening streets concern places where there were fields, or where there was land which could be given away for nothing ? They had one or two widening schemes in Holborn at the present time, and they were very fine, but the land would cost £2 10s. a superficial foot, and it was always a question whether the ratepayers would stand the expense.

Looking at matters all round, he thought that there was too much central authority. The only sort of central authority that he would like would be one individual who was paid £20,000 a year to manage the roads, the Metropolitan Boroughs being wiped out.

The paper spoke of the failure of local authorities to provide highways sufficient for present-day traffic. He went up and down the country and saw many highways, and the other day he was walking along the road between Saffron Walden and Cambridge, and he considered that road a perfect one. Taking the United Kingdom as a whole the roads were good.

TABLE A. NEW OXFORD STREET.

Paved in year	Maintenance years.	Material.	Cost.	Cost of maintenance.	Maintenance rate per yard super per annum.	Area in yards super.
			£	£	s. d.	
1878	—	3in. × 9in. × 6in. Fir Blocks on 6in. concrete & ½in. asphalte	5,518	—	—	6,872
	1878-1880	—	—	Free	—	—
	1880-1883	—	—	1,203	1 0	—
1883	—	2in. asphalte on 6in. concrete	4,409	—	—	6,843
	1883-1885	—	—	Free	—	—
	1885-1889	—	—	3,060	0 8	—
	1889-1897*	—	—		0 10	—
1897	1897-1909	2in. asphalte on existing foundation	—	8,542 (and cost of repairs)	1 10	7,270
1909	—	2in. asphalte on 6in. concrete	5,413	—	—	6,645
	1909-1911	—	—	Free	—	—
	1911-1913	—	—	Cost of repairs £1,234	—	—

Total cost per yard super per annum over 35 years = 2s. 5d.

Length of Street, 1,714ft. = 571 yards.

*Maintenance increased.

TABLE B. HIGH HOLBORN.

(BURY STREET TO DANE STREET.)

Paved in year	Maintenance years.	Material.	Cost.	Cost of maintenance.	Maintenance rate per yard super per annum.	Area in yards super.
			£	£	s. d.	
1879	—	Fir wood on 6in. concrete and ½in. asphalte	3,911	—	—	5,742
	1879-1881	—	—	Free	—	—
	1881-1885	—	—	1,148	1 0	—
1885	—	2in. asphalte on 6in. concrete	4,403	—	—	5,915
	1885-1887	—	—	Free	—	—
	1887-1902	—	—	3,697	1 0	—
1902	—	2in. asphalte on existing foundation	3,521	—	—	5,948
	1902-1904	—	—	Free	—	—
	1904-1910	—	—	3,519	2 0	—

Total cost per yard super per annum over 31 years = 2s. 2¾d.

Length of street, 1,136ft. = 379 yards.

Table C. HIGH HOLBORN.

(Dane Street to Grays Inn Road.)

Paved in year	Maintenance years.	Material.	Cost.	Cost of maintenance.	Maintenance rate per yard super per annum.	Area in yards super.
			£	£	s. d.	
1886	—	2in. asphalte on 6in. concrete	4,127	—	—	7,265
	1886-1888	—	—	Free	—	—
	1888-1903	—	—	5,237	1 0	—
*1903	—	2in. asphalte on 6in. concrete	—	1,090	1 6	7,265
1905	—	2in. asphalte on existing foundation	4,328	—	—	7,431
	1905-1907	—	—	Free	—	—
	1907-1910	—	—	1,393	1 6	—

Total cost per yard super per annum over 24 years = 1s. 10d.

Length of street, 1,567ft. =522 yards.

* Extension of existing contract at increased maintenance.

In 1910 this roadway was repaved by the Val de Travers Asphalte Paving Co., the Council paying £3,000 cash for portion of these section (Gray's Inn Road to Kingsway), and entered into a 12 years' Maintenance Contract at 2s. 3d. per yard superficial per annum.

For the remainder of High Holborn (Kingsway to the Council Offices) the Council in the same year agreed to pay 2s. per yard superficial per annum for maintenance. This Contract was determined March, 1912.

In September last year that portion of the road between Council Offices and Kingsway was repaved by Messrs. John Mowlem & Co. with 5in. by 4in. Norwegian granite blocks on a 12in. Portland cement concrete foundation, at a cost of £3,114.

Mr. W. F. Owsley said that the author had given the cost of maintenance per mile up to March 31st, 1909. It would be interesting to have the figures up to date, as there had been a considerable number of motor vehicles put on the road since then.

Reply.

Mr. C. H. Cooper exhibited a series of lantern slides on the screen showing (i.) The effect of skidding wheels on road surfaces ; (ii.) large stones projecting above road surfaces ; (iii.) the effect of the large stones in road surfaces in destroying the waterproofing of surface dressings ; (iv.) effect of motor traction on inclines.

Referring to the view expressed by the President that adjoining owners should be compensated, he did not advocate confiscation, and there was nothing in his paper that implied confiscation. All that he intended was that people should be paid for what they had got, and that they should not be allowed to create, on ground which would be required for widening, something for which the ratepayers would have to pay excessive compensation. The question of compensation for subsoil had been alluded to but he would ask why the adjoining owner should be compensated for the subsoil that he could make no use of unless there was coal beneath, which undoubtedly he should win if at sufficient depth. Otherwise there was absolutely nothing for which compensation should be given. In the case of the Tube Railways, borings for which were made at a considerable depth, the compensation paid to the owners was merely nominal.

With regard to the question whether the local authority would be impartial in dealing with an undertaking such as laying a main which would compete with the undertaking of the local authority, he thought that it was a great pity that a local authority should ever go into competition. If they did then some other authority should become the licensing authority which should regulate the position of such main. The President had alluded to the question of roads laid long before they were required. He thought that the only decent feature of the recent Finance Act was that it tended to prevent estates being laid out at too early a date. It would be a good thing if a greater tax was instituted in order to prevent land being taken from agriculture and laid out before it was wanted as sites for houses. It was admitted that the roads in England were the best in Europe. To-day Irish roads were far inferior to those in England, but twenty years ago the contrary was the case. He well remembered the oolite roads, which were the worst roads he had seen.

With regard to the Local Government Board being a controlling authority, the Board had no controlling power so far as highways which were paid for out of local rates were concerned. The paper was dead against a central authority having executive powers, and it referred merely to an administrative central authority. With regard to what was said about asphalte and bitumen, as far as the paper was concerned these terms were synonymous.

He was afraid that Mr. Killick, in mentioning the filling up of voids, had forgotten that, if they were to obtain a road surface which would resist heavy traffic, there must be a certain amount of tenacity in the road surface, but that would be entirely destroyed by the use of large stones. There was no doubt that when MacAdam said that they should not put into a road a stone which was too large to go into a man's mouth, and that they should not put one in that would not fill his mouth, he was about right.

He (Mr. Cooper) thought that if any gentleman had proved that what the paper said was correct it was Mr. Max Clarke. He had criticised what the paper said with regard to a central authority, but had himself said that the very best thing that could happen to the Metropolis would be the wiping out of the Metropolitan Boroughs, and the appointment of one man to manage the roads of London. Mr. Cooper did not go so far, but what he did say was that so far as administration was concerned it should be under one authority.

The question of forecourts had been referred to by Mr. Newton. In the case of the street leading to the " Angel " Tavern from Paddington, an Act was passed to prevent the forecourts from being built upon. If that Act was carried out what would have been the value of the forecourts to the freeholders ? Merely the value of such forecourts as garden land or open spaces.

In reply to Mr. Van Putten, he would say that the slides exhibited showed the effect of motor 'bus traffic, the double-tyred hind wheels of which caused excessive damage where depression in the road surface occurred. Tram tracks took a large amount of traffic so long as the paving was in good condition, but this did not compensate for the nuisance and danger that resulted from their presence.

What Mr. Killick had told the meeting as to the wear on county road surfaces was most instructive, but the fact that such wear was confined to a width of 18ft. was no reason why sufficient space should not be allowed for rapid traffic to pass, or that the space between hedges should be so restricted that vehicles could not view one another.

November 3rd, 1913.

H. C. H. SHENTON, VICE-PRESIDENT,
IN THE CHAIR.

ACCRETION AT ESTUARY HARBOURS ON THE SOUTH COAST OF ENGLAND.

By GERALD O. CASE (Member).

A NEW cycle of coastline changes is inaugurated by any important alteration in the relative levels of land and sea. In late geologic times there was a fairly rapid, but intermittent, subsidence of the land, or rise of the sea, which Mr. Clement Reid, F.R.S., thinks may have been completed about 3,500 years ago. As a result a great part of the former coastal plain was flooded, and the lower parts of the valleys submerged, thus forming on the south coast of England numerous sea-locks or fjords which penetrated considerable distances into the land. The valleys into which rivers discharged were formed into estuary harbours, which in early historic times abundantly sufficed as safe and commodious havens for the vessels then in use.

As a general rule, the sea erodes headlands, transports the mud to deep water, and fills up indentations in the coast with the coarser material thus obtained. In the case of tidal estuary harbours, the river transports from its drainage area mud and fine silt, and deposits some of the material in the estuary.

There is abundant evidence to show that accretion has gradually taken place at the natural harbours of the south coast of England. As the size and number of vessels increased, the size of the natural estuary harbours therefore decreased. In course of time it became necessary to make artificial improvement and in some cases to construct semi-artificial or artificial enclosures.

An intimate knowledge of the causes of accretion is of the greatest importance to the harbour engineer ; in the past accretion has destroyed the utility of many good natural harbours, and at the present time an enormous sum of money is spent annually in dredging or otherwise getting rid of material which accumulates inside harbours, or in the form of bars which obstruct the entrance.

SOURCES OF SUPPLY OF MATERIAL.—It may be stated as a general principle that the land is the only source of supply of material forming accumulation in front of or in tidal estuaries. The erosion of cliffs by the action of waves and sub-aerial agencies results in the formation of shingle and sand available for littoral drift, the finer particles of mud or silt being deposited on the sea bed in deep water beyond the zone of progressive alongshore movement. In the case of the large rivers a certain amount of shingle and sand is derived from the land, and is transported by them to the sea coast. The mud which accumulates in sheltered situations in tidal estuaries is, no doubt, mainly derived from the drainage areas of the rivers, and deposited before reaching the exposed parts of the sea coast.

While in a few cases the mud and fine silt deposited in tidal estuaries is derived from erosion of the neighbouring coast, in the author's opinion this is not the main source of the supply. Bays on the coast into which an inappreciable amount of land water is discharged have filled in the past and are now filling with sand. It would therefore seem reasonable to suppose that the supply of sand for filling up tidal estuaries may either be brought in by the sea from the neighbouring coast zone of littoral drift, or be brought down by the river from its drainage area.

A few engineers have advanced the theory that the sea bed is one of the sources of supply of foreshore material. While under exceptional conditions it may be eroded, and sand transported therefrom to the zone of littoral drift, there is no doubt that the sea bed is the ultimate destination of all the products of sub-aerial and marine denudation.

Travel of Material.—The cause of the alongshore travel of shingle is undoubtedly the wind waves, the direction of travel being governed by the prevalent onshore winds. The movement of sand along our coasts is chiefly controlled by tidal, wind, and other currents ; the work of the waves on the land margin being principally to stir up the sand for the currents to transport.

Formation of Shingle and Sand Spits.—On coasts where there is a predominant drift in one direction, and a large available supply of shingle or sand, spits are built out from the mainland on the windward side, across tidal estuaries. The sand or shingle is moved by the waves or currents in a more or less continuous manner, and where there is a sudden indentation in the coast, as in the case of tidal estuaries, the sea builds out a spit approximately in line with the main coast on either side of the estuary instead of moving the material back into the re-entrant angle on the windward side.

While at first the spit is built out in the direction of the shore line on the leeward side, in course of time it often follows a gentle curve towards the shore, the convex face being presented to the sea. In time the spit may extend right across the estuary, and in such case its continued growth will divert the river alongshore, and its outlet may be several miles to leeward of its original position.

If, from any cause, the alongshore supply of material is greatly reduced or cut off, the sea end of the spit generally shows a marked landward deflection, in the form of a hook. On the south coast, hooks have also been formed during the growth of the spit by strong south-easterly gales.

As a spit growing across a tidal estuary increases in length, the area of the tidal basin increases and consequently the end of the spit becomes subject to an increasing tidal scour which may prevent it growing longer. Where there is a plentiful supply of littoral drift and the alongshore growth is hindered by the river outlet, an apposition type of spit is formed on the windward side of the outlet, owing to the formation of successive ridges or fulls of beach in front of one another.

The river water during floods sometimes breaks through the spit, the result being the formation of one or more long narrow islands, but if the supply of littoral drift is plentiful, the remaining portion of the spit on the windward side again grows out across the estuary.

When spits have been built up by sea action to about the height of low water neap tides, the wind sometimes plays an important part in their formation. On sandy shores at low tide, the inshore winds blow the sand against the sea-constructed shingle or sandbank, and wind-formed dunes are brought into existence. Above high-water level of ordinary spring tides vegetation often actively assists in collecting and fixing the inblown sand. Not only does the wind transport sand to the spit at low tide, but it also helps to fill the sea bed or foreshore on the land side, fine sand which is not retained by vegetation being blown over.

FORMATION OF SALT MARSHES UNDER SHELTER OF SHINGLE AND SAND SPITS.—Accretion of the sheltered areas at the natural estuary harbours of the south coast has been largely brought about by the action of vegetation.*

As soon as a spit has been formed part of the way across a tidal estuary, the accretion of sand, mud, and fine silt begins to take place, and the result is the formation of salt marshes, which eventually are built up to the level of about ordinary high spring tides. In the formation of salt marshes, vegetation plays a very important part, and one which has not been fully recognised in the past. The river and tidal currents transport the silt and sand, and the vegetation organises and controls the accretion, and causes it to take place at a much more rapid rate than it otherwise would. The plants which grow on the sea bed and foreshore slow down the currents, and cause material to be deposited which in their absence would be held in suspension and moved away. Numerous marine animals dwell among the plants, and their remains and the decay of the plants themselves assists in forming a fertile soil. The factors at work on the sheltered shore of an estuary may be regarded as forming collectively a machine for building up a soil on the foreshore and gradually reclaiming it from tidal action.

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* *Vide* "The Use of Vegetation for Reclaiming Tidal Lands," by G. O. Case, *Engineering*, August 22nd and September 12th, 1913.

On the sea bed below the level of the lowest tides, zosteras are very important as agents of accretion. The sea grass *Zostera marina* grows in dense masses on the sea bed in numerous tidal estuaries. The bladelike leaves are very strong and capable of withstanding waves which occur in moderately sheltered places. The effect of zosteras in raising the surface is confined to areas below low water level of spring tides ; other kinds of plants then take up and carry on the work began by the zosteras in deep water.

The colonisation of the foreshore between the tide limits is a process of many stages, each paving the way for the next. Algæ and bacteria are followed by the first phanerogams, namely, various species of salicornia, and then by other plants.

In recent years Prof. Oliver, F.R.S., has devoted considerable time to studying the action of vegetation in building up salt marshes.* On bare sandy foreshores in estuaries which are covered by spring tides, certain species of seaweed which cover the sand with a kind of felt work, play an important part in the pioneer work in connection with the salicornias. The perennial variety (*S. radicans*) is very effective as a sand collector. It grows on the sand banks in belts transversely to the direction of the incoming tidal current, and by checking its velocity causes sand to deposit on the lee side of the belt of plants. After the salicornia have formed sand hummocks the latter become colonised by glycerias and other plants. As the sand hummocks are built up by the salicornias the plants spread laterally, the area and height of the hummock being increased simultaneously. After a time the annual salicornias also grow in the hollows between the hummocks, and help to raise the surface level. In course of time the hummocks become united, and to a certain extent levelled up, and a grassed-over salt marsh is formed.

After the glyceria suæda salt marsh has been formed, the process of accretion is still carried on, and as the surface is raised other kinds of plants establish themselves. When the marsh has been built up to the level of high water of ordinary spring tides further accretion proceeds at a very slow rate, as the marsh is then only flooded by a few high tides yearly.

At the Bouche d'Erquy, France, the sandy foreshore, Prof. Oliver states, has been raised 10in. in three years by the salicornias, and in some cases bare sand has been converted into turfed-over salt marsh in the course of three years. The advance of the salt marsh on the bare sands is at the rate of about 10 yards per annum.

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* F. W. Oliver, F.R.S., " New Phytologist," October, 1906 ; Evidence before Royal Commission on Coast Erosion and Reclamation.

On muddy foreshores *Salicornia radicans, Suæda maritima, Obione portulacoides, Glyceria maritima,* and other plants collect and fix the mud, but the method of accumulation differs from that which takes place on a sandy bottom.

On sheltered estuary foreshores where there is some mud mixed with the sand, Spartina grasses are very active agents in causing accretion. In places these grasses overrun large areas, hundreds or even thousands of acres of foreshore, the process of collecting material and forming a soil being rapidly accomplished.

Of the four species of Spartina grasses which grow in Europe, rice grass (*Spartina Townsendii*) is by far the most important as an active agent in causing accretion. This grass was first observed at Yarmouth in 1893, now it covers the mud banks of the River Yare and the adjacent salt marsh, the whole estuary being overgrown up to Freshwater. At the Beaulieu estuary it establishes itself on foreshore covered by 4 or 5ft. of water at high spring tides, and has overgrown some 2,000 or 3,000 acres in a few years.

Referring to Spartina grasses on the Hampshire coast, the Royal Commission on Coast Erosion and Reclamation in their final report state that " their roots and the bases of their dense clumps effectively fix the mud, and where the grasses occur in continuous beds they form a bank behind them, lessening the erosive power of the tides and currents. In time they will contribute to the raising of the mudbanks occupied, and when the high water mark has been reached, the ordinary salt marsh vegetation will step in and complete the process of natural land reclamation."

ESTUARY OF THE RIVER STOUR.—Between the Isle of Thanet and the mainland of Kent there was formerly a navigable strait into which the river Stour discharged its waters. This natural estuary harbour (Fig. 1) had an area of about twenty square miles, sheltered by the Isle of Thanet, and had two good entrances, the southern entrance being between Deal and Ramsgate and the northern entrance between Herne Bay and Westgate-on-Sea. At, and prior to, the first Roman invasion, what is now practically all dry land in the valley of the Stour was the finest harbour on the south coast of England. The southern entrance was, in the time of the Romans, guarded by the military station of Rutupiæ, and the northern entrance was guarded by the fortress of Regulbrium. Instead of going round by the North Foreland, vessels formerly sailed from Dover to London through this strait.

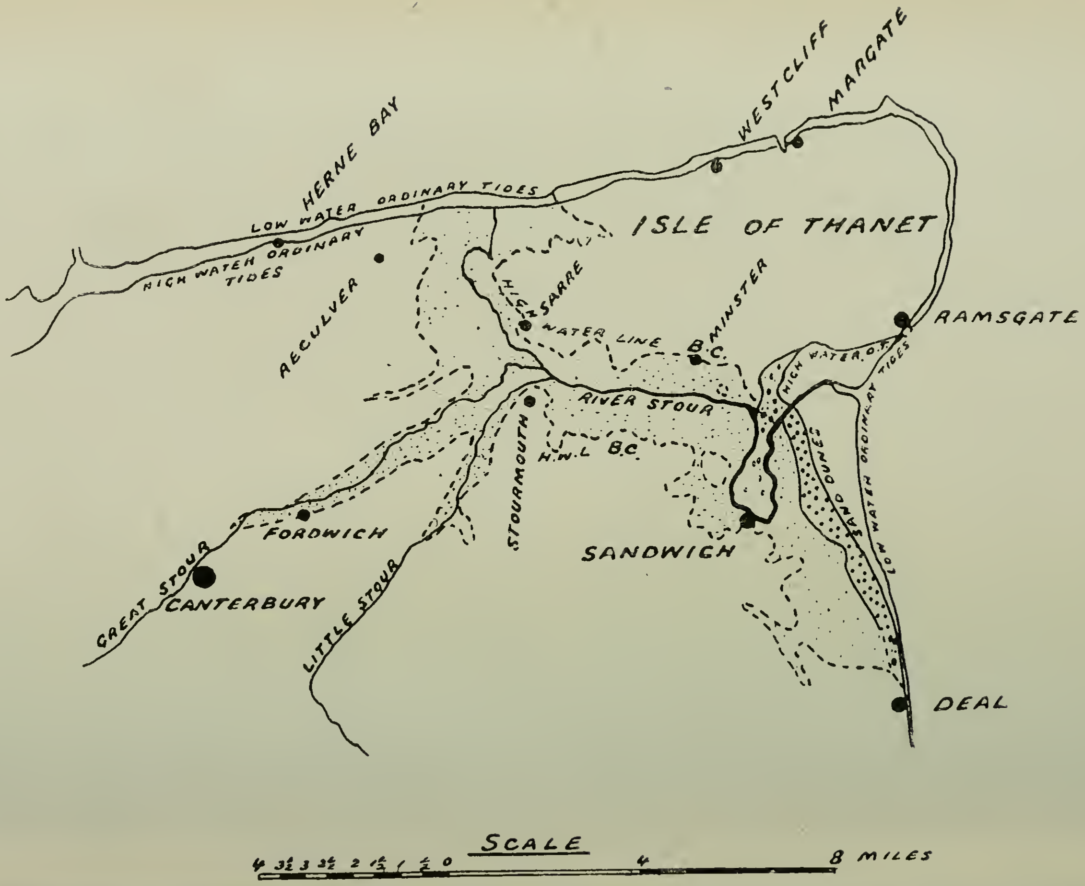

Fig. 1.—Plan of Stour Estuary showing High Water Lines before the Time of Christ and Now.

There is always a tendency for an outlying island to become joined on to the mainland by the formation of shingle spits from the island, and in some cases also by spits running out from the mainland towards the island.

There is no doubt that in the phase of youth the material eroded from the sea face of the Isle of Thanet was deposited in the form of two spits, one growing out from the Ramsgate end of the island towards Sandwich, and the other from Westgate towards Herne Bay. The remains of the first-mentioned shingle spit from three to four miles long can be traced now, and as is seen from the map of the district (Fig. 1), it drove the outlet of the Stour several miles towards Deal. A spit also grew out from the mainland at Deal in a northerly direction. This spit consists of a long ridge of sand dunes with an outer margin of shingle. It has gradually increased to northward, for from maps of the time of Queen Elizabeth, Sandown Castle appears to have been situated at its extremity, and took its name from the sand dunes, which preceded the accumulation of shingle.* Formerly, no doubt owing to the different contour of the coast, the north-easterly winds were effective in causing littoral drift from the island towards Sandwich, but such winds, striking the coast between Deal and Sandwich almost at a right angle, were not so effective in causing drift on this part of the coast as the south west winds.

After the spits had grown out across the entrance to the estuary, various plants commenced to grow on the sheltered foreshore, mud brought down by the Stour from its drainage area was deposited, and no doubt some sand brought in from the zones of littoral drift ; thus salt marshes were gradually formed, and as they were raised to about high tide level were enclosed by the construction of earth banks by the neighbouring landowners. In the case of Stodmarsh, embankments have shut out the waters of the Stour for a very long time. Owing to the water being excluded from some of the early inned lands, the natural accretion was thus stopped, and consequently the level of the land is lower than that of the surrounding marshes which were inned later.

In the case of this estuary, historical and other evidence enables us to trace fairly accurately the rate at which accretion took place.

A strong presumptive proof that the whole of what is now the marsh land in the Stour valley, and extending as far inland as Canterbury, was covered by the sea at the time of the Roman invasion, is found in the fact that no Roman remains of any kind have been found anywhere in the marshes, but numerous coins and other remains have been found in the rising land at its borders. Most of the site of the present city of Canterbury was formerly the bed of the Stour, when it was a tidal river as far inland as this. All through the Middle Ages, Fordwich, two miles below Canterbury, was the port of that city.

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* Redman, *Proc. Inst.C.E.*, *Vol. XI.*

Rutupiæ was the Roman name for the southern part of the estuary, and it is mentioned by numerous classical writers between A.D. 65 and A.D. 375*, being then a very important harbour. Solinus, writing in A.D. 238, stated that the Isle of Thanet was separated from the mainland by a narrow strait. Bede, in his "Ecclesiastical History," written about 736, tells us that the Isle of Thanet was then separated from Kent by an estuary about three-eighths of a mile wide and fordable at low tide in two places.

Sandwich is not mentioned as a port until about 300 years after the Romans left, and there is reason to suppose that part of the ground upon which it stands was covered by the sea at the time of their invasion. Eddi, in his "Life of St. Wilfred," written in 711, says that "with the help of God, and giving thanks to Him, they arrived safely at the harbour of Sandwich."

Various entries in the "Anglo Saxon Chronicle" show that between 993 and 1052 Sandwich was a very important harbour. In the first-mentioned year Olaf went there with 93 ships. In 1008 the king ordered a large fleet to be built to resist foreign invasion, and in 1009 it was brought together at Sandwich, there being, according to the chroniclers, "so many then as never before." In 1013 King Svein, and in 1014 Canute, visited Sandwich with fleets. In 1045 King Edward "went with his ships to Sandwich, and there so great a force was gathered, that no man had seen any greater naval force in the land." In 1052 Earl Godwine went to Sandwich with a large fleet, and sailed through the Stour estuary to London. There is also historical evidence that the Cinque Ports navy transported the King's army from Sandwich to France in May, 1491, and brought it back again to the same port in 1492.

A record in Domesday shows that Ætheling Alfred took up a fleet to Canterbury in the eleventh century, and that the privilege of levying tolls on foreign merchants at that port was jealously asserted by the two monasteries of Trinity and St. Augustine's.

In King Canute's reign (1017-1035) a grant was made of the port of Sandwich to the Prior of Christ Church, Canterbury, which stated that the width of the channel was such that a man might fling a hatchet ashore from a vessel riding in the middle at high tide.†

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* Sharpe, *Britain B.C.*

† Lewis, Paper read before Society of Antiquarians, 1774.

Dowker thinks that the estuary ceased to be navigable for merchandise* from Sandwich to Reculver after the twelfth century. It was certainly navigable as far as Minster in 1242, for in that year the Prior and Chapter of Christ Church, Canterbury, entered into an agreement with the Abbot and Convent of St. Augustine's with reference to the passage of vessels between Sandwich and Minster.

The Rolls of Parliament, 1485, show that the estuary at Sarre was so " swathed, growen and hyged with wose muddle and sand that no fery may be there," and consequently permission was asked to build a bridge.

About 1509 it was proposed to make the Stour navigable between Fordwich and Canterbury, and some time previous to 1529 a Commission was appointed to devise a scheme for the improvement of the port of Sandwich. In their report they stated that within a few years past large ships were accustomed to ride there without difficulty, but they judged that the restoring of the haven seemed to be impracticable at that time.

In a report made by Sir Walter Raleigh to Queen Elizabeth he states that although Sandwich was a good harbour in Henry VIII.'s reign, it was then " extreamly decayed."

The natural accretion which gradually took place was occasionally retarded by exceptional storms, and some of the embankments were breached. In 1328 King Edward caused a writ to be issued calling upon the See of Canterbury to inspect certain of the earth banks which had been broken through, and to do the necessary repairs and effectively to maintain the said banks.

As soon as sufficient accretion has taken place in an indentation to make the coast in approximately a straight line, a cycle of erosion commences. Thus we see that previous to the 13th century the indentation in the coast between Westcliff and Herne Bay was slowly filling up, but as soon as the coastline was straightened erosion began to take place over the whole length of coast from the North Foreland to beyond Herne Bay, the rate of erosion being the same as that of the shore on either side, which had steadily taken place while the accretion was going on in the indentation. Here we see an example of natural accretion taking place for hundreds of years, and then the reverse process suddenly commencing.

Estuary of the River Rother, Kent.—One of the most interesting examples of coast accretion around the British Isles is that which has taken place in and in front of the Rother estuary. As a result the ancient harbours of Hythe, Romney (two of the Cinque Ports), and Appledore are entirely silted up. Rye harbour has ceased to be navigable except for small ships, and over

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* Proceedings, East Kent Historical Society.

70 square miles of land have been reclaimed from the sea, including that wonderful shingle formation known as Dungeness Point.

The outline of the coast at the commencement of the present cycle of coastline changes is shown in the accompanying plan (Fig. 2).

FORMATION OF SHINGLE SPIT FROM FAIRLIGHT CLIFF TO HYTHE.—There is no doubt that a comparatively narrow shingle spit grew out from Fairlight cliff in an easterly direction towards Romney, which was then an island, and when it had reached there grew out again towards Hythe, the outlet for the waters of of the River Rother and its tributaries being thus gradually driven eastwards until eventually there was a continuous shingle spit extending from Fairlight cliff on the west to between Lyme and West Hythe on the east. At that time the river was called, the Limene or Lymene. Dungeness Point could not, therefore, have existed then. At the present time (Fig. 3) its growth seaward effectively prevents the eastward travel of shingle, and there is abundant evidence that formerly the shingle travelled freely from Fairlight Cliff to Hythe. There is also direct evidence that the coastline was formerly some distance inland of the present Point.

Nearly four miles inland of Dungeness Lighthouse there is the Lydd shingle spit over four miles long, on the north side of Denge marsh (Fig. 2), which is shown on Cole's map, dated 1617, and on maps made by the late James Elliott, M.Inst.C.E., about 1845. Historical evidence also goes to prove that Lydd was formerly on the coast.*

In addition to the Lydd portion, the ancient shingle spit can also be traced on the east side of New Romney, and there is strong evidence that there was a continuous spit on the line where the Dymchurch wall now stands, for throughout its whole length there are shingle banks running under it. There are also traces of short spits at right angles to the wall, which were, no doubt, formed by the end of the main spit being occasionally turned by south-easterly gales during its growth eastward.†

LYMNE AND HYTHE HARBOURS.—There is no doubt that when there was a continuous spit from Fairlight Cliff to Lymne, near Hythe, first Lymne (Portus Lemanis) and then later on Hythe were very important harbours. As often occurs when a shingle spit is hindered from increasing in length by a river outlet, successive ridges of beach, or what is termed an apposition spit, was formed near Hythe, and is now used by the War Office for rifle ranges. At West Hythe the parallel series of curved ridges can now be seen running in a south-west direction. Opposite Moncrief Fort the surface for a distance of about two miles is com

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* Redman, *Min. Proc. Inst.C.E. Vol. XI.*

† Elliott, *Min. Proc. Inst.C.E. Vol. XI.*

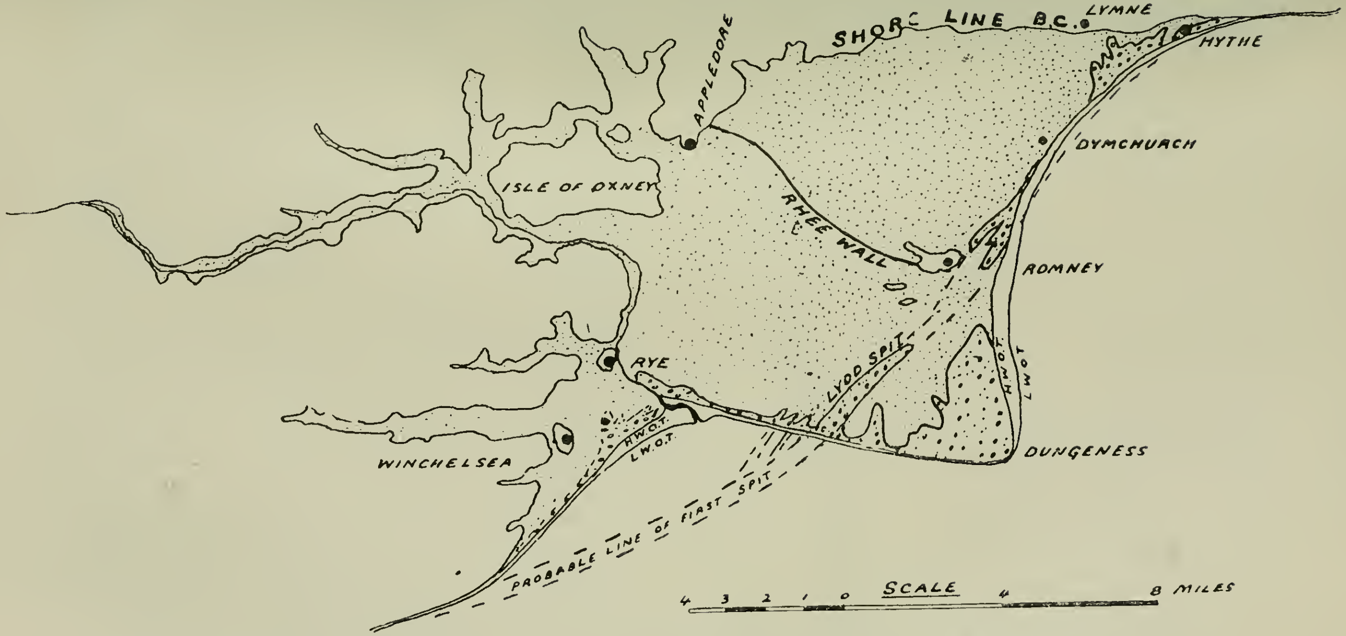

Fig. 2.—Plan of Rother Estuary showing High Water Lines before the Time of Christ and Now.

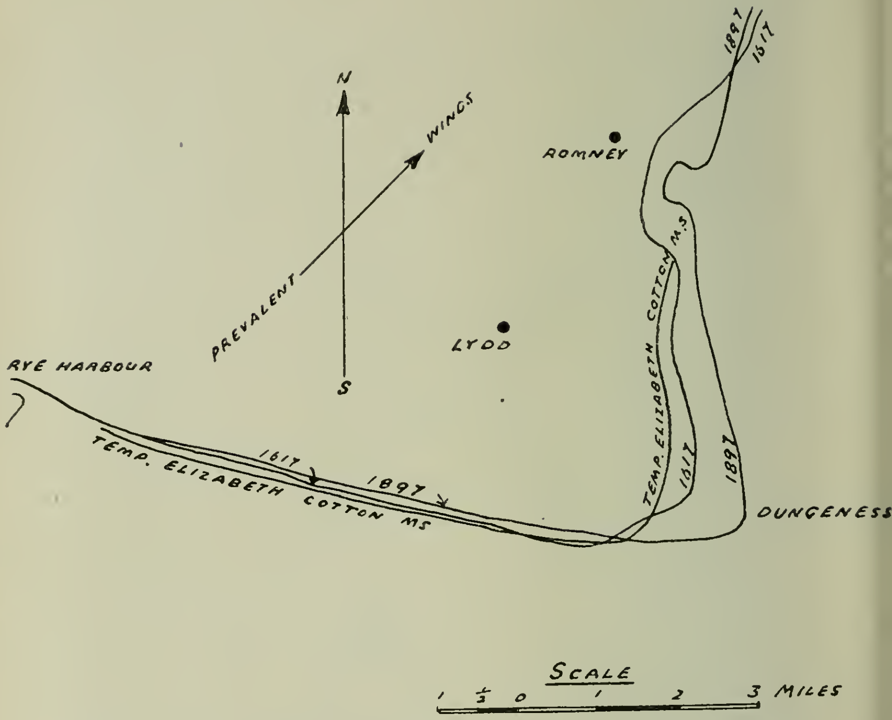

Fig. 3.—Plan showing Alterations in Coast Lines at Dungeness since the Time of Queen Elizabeth.

posed of successive ridges, denoting periodical accessions to the coast.

As was the case at other estuary harbours, considerable accretion took place behind the shingle spit, salt marshes being formed partly by mud brought down by the river and partly by the deposition of sand brought in by the tides. In the Memoir of the Geological Survey it is stated that in different parts of the marsh deposits of sea sand are found. The highest parts of Romney Marsh are those nearest the shingle spit, and it is evident that salt marshes were formed there first, and that on the ebb of the tide the water flowed towards the hills where the low water channel of the river was situated, and thence out to sea at the outlet near Hythe.

Romney Marsh proper was all reclaimed at one time by the construction of the Rhee wall from Appledore to New Romney. This was probably made after a storm had broken through the shingle spit, causing the main part of the river waters to flow out at the latter place. No record is to be found of the date of the construction of this bank, but it must have been built before the time of the Romans or by them, for extensive Roman remains are found over the whole of Romney Marsh.

After the construction of the Rhee wall, as late as Queen Elizabeth's reign, there was still at Hythe an inlet of the sea which had two arms, one extending towards Lymne, and one towards Folkestone, but owing to the river outlet being at Romney these slowly silted up.

There is no doubt that after the diversion of the Rother to Romney the western channel of the old river bed between Lymne and Appledore gradually silted up by the deposit of sand brought in by the tides until it became a mere stream. Between 697 and 833 numerous grants by the kings were made to different monasteries of pasture marsh on the south of the Limene channel.

From the Itinerary of John Leyland, written in 1546, we learn that Hythe harbour then " liith meatly strayt for Passage out to Boleyn. It croketh yn so by the Shore a long, and is so bakked from the mayn Se with casting up of Shinggil that smaul Shippes may cum up a large Myle toward Folkstan as yn a sure Gut. Lymne Haven or Lyme was sometime a famous Haven and good for Shyppes that might come to the Foote of the Hille." Towards the latter end of the sixteenth century Hythe ceased to be a port owing to the entrance being blocked with shingle.

ROMNEY AND APPLEDORE HARBOURS.—After the Romans left, until about 1287, the outlet of the Rother was at Romney, this place being the outer port and Appledore at the foot of the hills the inner port, there being a broad channel between the two places navigable for large fleets of that time, and also a navigable channel from Romney to Rye and Winchelsea. In the charter, dated 774, by which King Offa made a grant of Lydd, it is stated that the sea then flowed on the north and east sides of that place. Although the mouth of the Rother must have been westward of the Rhee wall after its construction, the first record I have been able to find of the entrance being at New Romney is the charter of Eadbright, dated 741, which states that " I, Eadbright, King, by Surname Eating, for the salvation of my soul, grant to the Church of Christ in Canterbury, the fishery at the mouth of the River Limene, and part of the land which is situated the Vill St. Martin " (afterwards Romney).*

In 893 the Danes came over with a fleet of 250 ships and disembarked at Appledore. The Anglo-Saxon Chronicle states that the Danes " towed up their ships four miles from the outer harbour " (Romney). From the same source we learn that in 894 a large army was landed at Appledore.

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* Burrows, " Cinque Ports."

Romney was no doubt a flourishing port until near the end of the 13th century, when, as all the old chroniclers tell us, an exceptional storm visited this part of the coast, and destroyed a long length of the shingle spit between Fairlight Cliff and Lydd, submerged old Winchelsea, and made a new opening for the Rother waters at Rye. After the destruction of this part of the spit all the low lands formerly reclaimed around Winchelsea and Rye, were submerged, and the present Winchelsea was built on an island to the north-west of the old town.

There is no doubt that this storm turned the western end of the Lydd shingle spit inland and altered the contour of the coast westward of Romney.

After the new outlet of the Rother was formed at Rye very little river water flowed out at Romney, and consequently the bed of the channel between there and Appledore gradually silted up, although repeated efforts were made to keep open the harbour. A bad storm in 1334 appears to have drifted a large quantity of shingle in front of it, and further reduced the inlet.

From 1150 to Queen Elizabeth's time, grants by letters patent were made of parts of the old bed of the Rother to the adjacent landowners on either side and to the Corporation of New Romney. Dugdale, in his history of Imbanking, tells us that, about 1358 King Henry III. "had advertisement that his Haven of Rumenale was in great danger of destruction to the no little damage of the publick and excessive annoyance of the Towne of Rumenale." On the advice of Nicholas de Hanlon, who reported thereon, the bed of the channel was cleared of obstructions, and three sluices built, but the work was not a success.

There is a record that in 1401 expenses were incurred for making and digging part of the bed of the old river channel; this no doubt referring to efforts made to keep open the remaining part of the inlet at New Romney which then formed the harbour.

John Leyland, writing in 1546, stated that Romney "hath been a metely good haven, in so much that withyn remembrance of Men Shippes have cum hard up to the Towne, and cast Ancres yn one of the Church Yardes."

On the west side of Romney the former channel of the Rother can still be traced, the ground being lower than the surrounding marshes, with walls or banks on each side.

RYE HARBOUR AND WINCHELSEA.—Between 1154 and 1187 Winchelsea and Rye were called upon to supply ships for state purposes, and were granted the same privileges as the other Cinque Ports. From about this time onwards these towns built and supplied a number of ships. It seems uncertain whether a storm about this period made an opening in the shingle spit between Fairlight Cliff and Romney, or whether the ships from these ports used the opening at the latter place, but there is no record that the Rother water discharged west of New Romney until after the storm which destroyed Old Winchelsea. Subsequent to this storm, when the river Rother outlet was at Rye, this town was a more important harbour than Romney. In course of time, however, a new shingle spit formed at Fairlight Cliff, and grew out towards the west end of the remaining Lydd spit.

A survey of this part of the coast made by Sir Thomas Palmer in 1587 shows the outlet of the Rother to be much impeded with shingle, and that the interior harbour was rapidly shoaling up.

From a report made to Queen Elizabeth by Sir Walter Raleigh it appears that Rye was a commodious haven in 1509, but that by 1600 the harbour was much impeded by accretion.

The reports made by Capt. Dumner and others for the Royal Navy in 1698 state that the harbour was then in a very bad condition, there being only from 2 to 4ft. of water in the entrance channel at low tide. The interior harbour was dry at low tide except for some " gleeting of Freshes from the country " ; the only space for vessels to lie at low tide being in the very entrance, and just within, which was only capable of floating a few fishing boats.

FORMATION OF DUNGENESS POINT.—There is little doubt that the formation of Dungeness commenced after the river outlet was made at Romney and the Rhee wall constructed. As we have already seen, an apposition spit was built up at Hythe when the Rother outlet was there. Similar formations are found at the outlets of other tidal rivers. The origin of Langley Point may be traced to the former existence of the tidal harbour of Pevensey to the leeward.

The successive ridges of shingle formed at Dungeness on the west side of Romney, owing to the eastward movement of shingle being interfered with by the tidal water discharged from the estuary harbour, which then had a high spring tide area of about 30 square miles.

In his paper on " Dymchurch Wall,"* the late Mr. J. Elliott suggested that some work of the Romans at the Port of Romney may have formed the nucleus of Dungeness, but the author thinks that the discharge of water from the tidal basin existing at this early period is quite sufficient to account for the collection of shingle which took place to windward.

Another theory had been advanced : that the original cause of the formation of Dungeness was due to the tides meeting there. The objections to this theory are, first, that a comparatively straight spit first formed from Fairlight to Hythe ; second,

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* *Min. Proc. Inst.C.E. Vol. XI.*

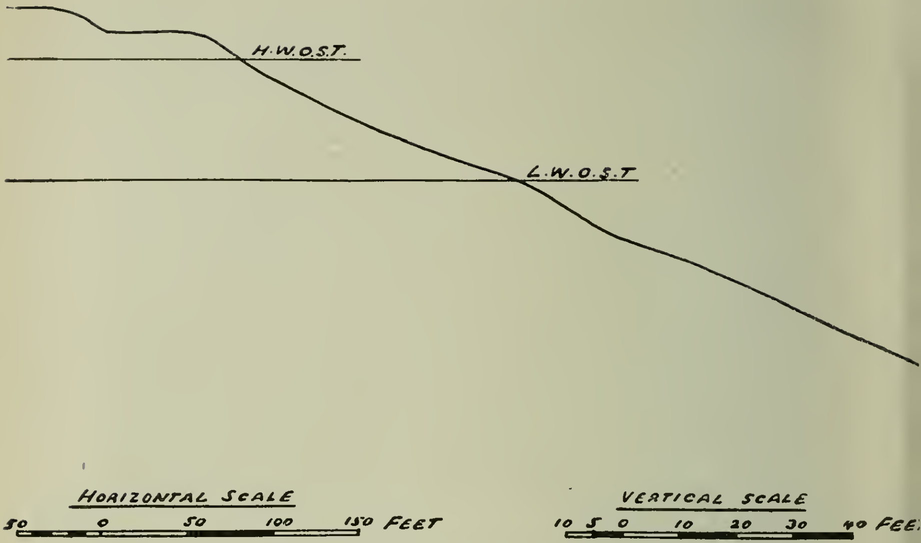

Fig. 4.—SECTION OF SHINGLE FULLS, FORESHORE, AND SEA BED AT DUNGENESS POINT.

similar formations projecting from the coast have been formed in places where no such meeting of the tides could take place.

In course of time the successive ridges of shingle formed a small headland, the erosion on the east side due to the supply of shingle being cut off, no doubt, also assisted in the elongation of the Point.

When the shingle spit in front of Winchelsea and Rye was destroyed, the shingle on the west side was pushed inland, this again tending to lengthen Dungeness with reference to the coast on either side. Owing to the supply of shingle from the westward being thus temporarily cut off, erosion took place on the west side, the shingle from there being moved to the Point.

It may be suggested that if the formation of Dungeness was due to the outlet of the Rother to leeward, an apposition spit would have been formed on the west side of Rye after the river outlet was diverted there. The probable explanation of this is that owing to silting and the reclamation of large areas of salt marshes, the tidal capacity of Rye Harbour was nothing like as great as that when the outlet was at New Romney. Consequently, the amount of water flowing out at ebb tide was insufficient to prevent the travel of shingle across Rye Harbour to Dungeness. Certain it is that an enormous amount of shingle has travelled past to Dungeness, which has been increasing steadily in length since the river outlet has been at Rye.

The prevalent south-west winds are effective in transporting material to Dungeness, but the coast from there to New Romney is sheltered from the prevalent winds.

The charter of King Offa, dated 774, previously referred to, shows that the shingle in front of Denge marsh, which forms part of Dungeness, must have been formed previous to that date. Lambard, in his " History of Kent," written in 1576, states that " this cape lieth south of Romney, and is one of these places which Earl Godwin afflicted in his time of banishment (1053)."

Old maps show that between 1586 and 1797 the advance seaward of Dungeness Point was about 20ft. per annum. Trinity House records show that between 1792 and 1850 the advance seaward was 9ft. per annum, between 1850 and 1871 from 13 to 4ft. per annum, and between 1871 and 1897 about 8 feet per annum, necessitating the lighthouse being shifted seawards three times during the past century.

EROSION OF ADJACENT COAST SINCE FORMATION OF DUNGENESS.—Romney Marsh was formerly protected by the natural shingle spit, but when Dungeness grew out sufficiently to cut off the shingle drift to eastward, serious erosion took place between New Romney and Hythe, there being no shingle moved in to make up for that drifted eastwards by the prevalent wind waves. In course of time, as the natural sea-constructed protective shingle bank was gradually weakened, it became necessary to carry out artificial works to prevent the sea from breaking through and flooding Romney Marsh. An earth bank was built on the land side of the shingle spit, and as the shingle was moved away the bank was from time to time faced with stone pitching. Now the whole coast, from a little west of Dymchurch to Hythe Redoubt, is protected by an artificial sea wall, built approximately on the site of the natural shingle spit, and by Case groynes in front of the wall.

In recent years it has become necessary to extend the artificial walling gradually towards New Romney, owing to the remaining piece of the old shingle spit being slowly eroded and weakened. The work now being done consists in the construction of a stepped concrete facing in front of the remaining part of the shingle.

In addition to the erosion eastward of New Romney, some loss has taken place on the west side of Dungeness ; the material removed therefrom being deposited between the Point and Romney Hoy.

THE ADUR ESTUARY, SUSSEX.—The levels of the existing land, the character of the soil, and the available historical and documentary evidence* prove beyond doubt that between Lancing and Shoreham there was at one time an inlet, about a mile and a half wide and having an area of over 800 acres, occupied by the sea (Fig. 5), this inlet forming the estuary of the river Adur.

At an early stage a shingle spit was built out across the estuary from the Lancing end of the mainland, in the direction of Shoreham. After the shingle spit was formed, an accumulation of sand and mud took place on the sheltered land side of it. The bottom was gradually raised, various species of plants commenced to grow, and salt marshes were formed, and these were from time to time reclaimed by the construction of earth banks by the adjoining landowners. At the present time a small area of the existing estuary near the Norfolk bridge is being converted into salt marsh by vegetation, amongst the plants doing this work are *Salicornia herbacea*, *Obione portulacoides*, *Suæda maritima*, *Aster tripolium* and *Glyceria maritima*.

When the shingle bank reached the west bank of the river channel, the mouth was gradually pushed eastward. A comparison of surveys of this estuary, made in 1587 by Sir Thomas Palmere, for the purpose of ascertaining if any defences were required at the river mouth to resist the Spanish Armada (Fig. 6), and by Edmund Dumner, in 1698, for the Admiralty (Fig. 7), it appears that between these dates the shingle spit drove the harbour mouth about 6,600ft. eastwards, or at the average rate of 59ft. per annum. In 1 59 the entrance was at Wish, Aldrington, so that between 1698 and 1760 the spit grew about 7,400ft. in length, or at the average rate of about 118ft. per annum.

In 1760 a cut was made in the shingle spit opposite Kingston, and two timber piers were built. Nothing was done in the way of artificial works at Wish to close up the old entrance, but in the course of three months, sufficient shingle had accumulated, in the form of an extension of the shingle spit, towards the mainland at Aldrington, to make it impassable for vessels, and in 1761 the entrance was entirely closed by the prolongation of the shingle spit.

In 1763, the artificial entrance at Aldrington was destroyed by a storm, and the entrance then gradually moved eastward again. Between 1763 and 1815 it traversed 7,200ft., or at the average rate of about 135ft. per annum.

While the harbour mouth was thus travelling eastward subsequent to 1763, the entrance always faced west-south-west. This was due to there being an outer shingle spit transverse to the opening and joined to the western end of the shingle spit on the east side of the entrance. Mr. Chapman, C.E., who made a report in 1815, attributed this spit to the fact that the growth eastward of the shingle spit on the western side was necessarily

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* Sussex Archæological Collections.

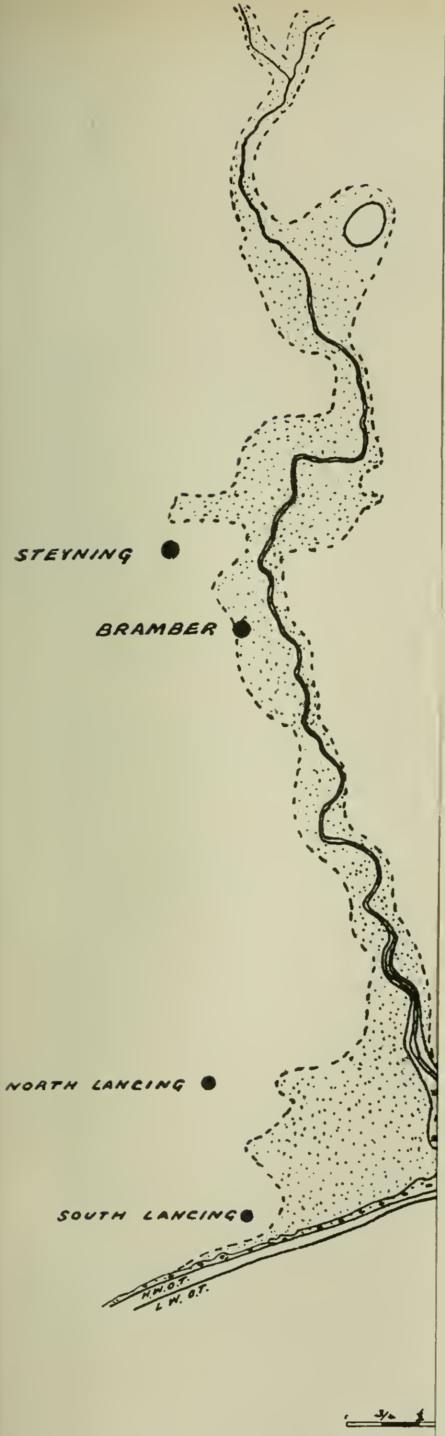

Fig. 5.—Plan of Adur Estuary sho

Journal of The Society of Engineers (Incorporated),
November, 1913.

CASE ON ACCRETION AT ESTUARY HARBOURS
ON THE SOUTH COAST OF ENGLAND.

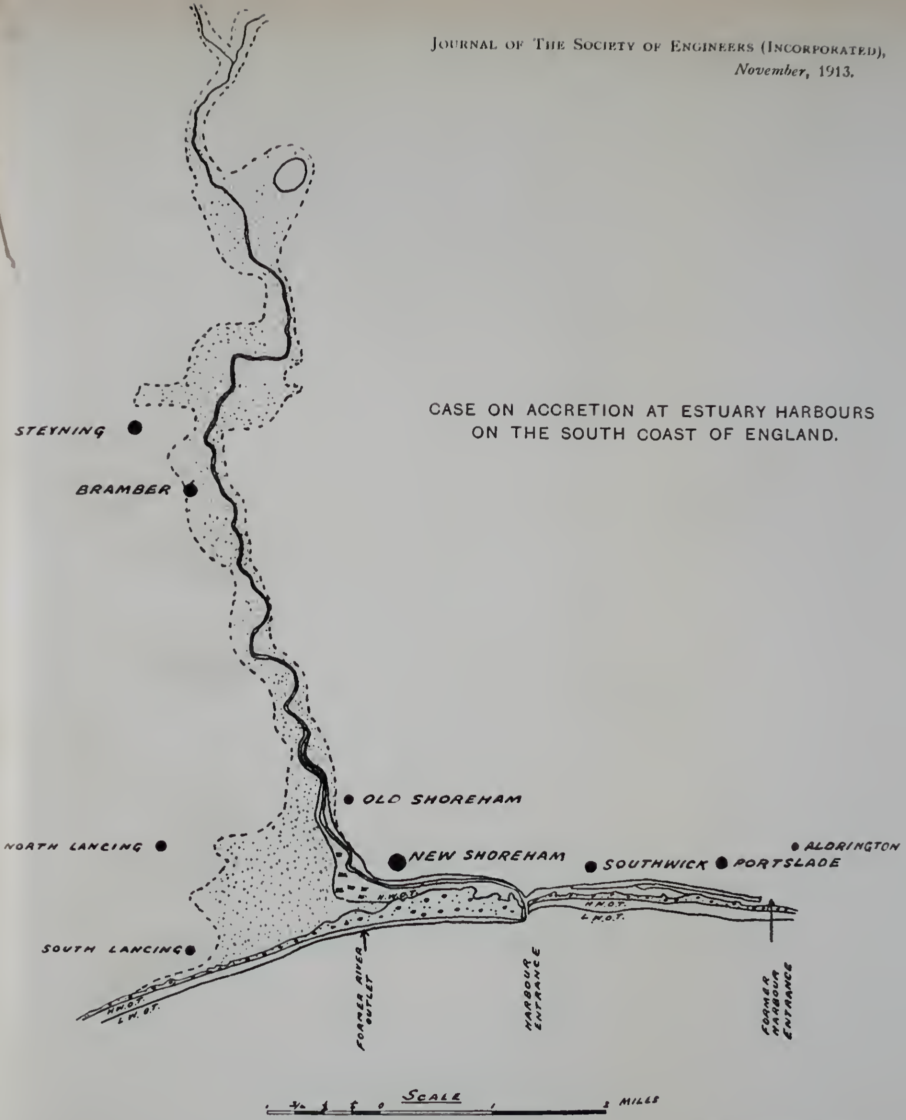

Fig. 5.—Plan of Adur Estuary showing High Water Lines before the Time of Christ and Now.

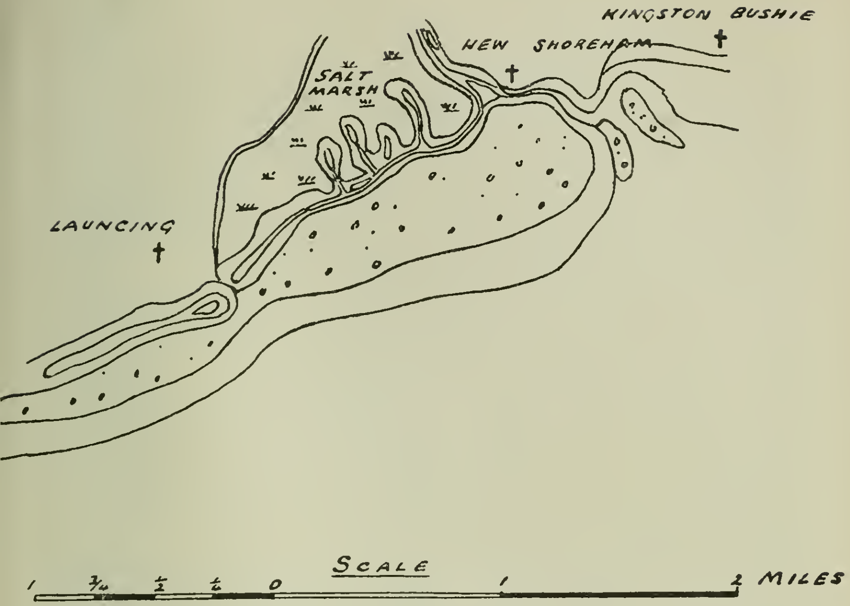

Fig 6.—Plan of Shoreham Harbour in 1587 from Survey made by Sir Thomas Palmere.

followed by erosion on the west end of the spit on the eastern side ; the shingle thus moved away being formed into the transverse spit referred to.

After the passing of the Shoreham Harbour Act, in 1816, the present artificial entrance was again made at Kingston.

From the available historical evidence it is possible to trace with some degree of accuracy the rate of the formation of the salt marshes and the gradual silting up of the natural estuary harbour.

The first port was at Steyning, now about 5½ miles inland of the present harbour, and this was no doubt the ancient "Portus Adurni." An agreement, dated 1103, between the Abbot of Fècamp and De Broase, Lord of Bramber, mentions that in the days of Edward the Confessor (1042-66) ships then used the Portus St. Cuthmanni, Steyning, but that in 1103 the harbour was much impeded by accretion.*

Camden, writing in 1607, stated that vessels which formerly came up to Bramber under sail could not do so in the time of Queen Elizabeth owing to the "burres of sand cast up at the river's mouth." In course of time, owing to the silting and formation of salt marshes, Old Shoreham succeeded Bramber and

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* Round, "Feudal England."

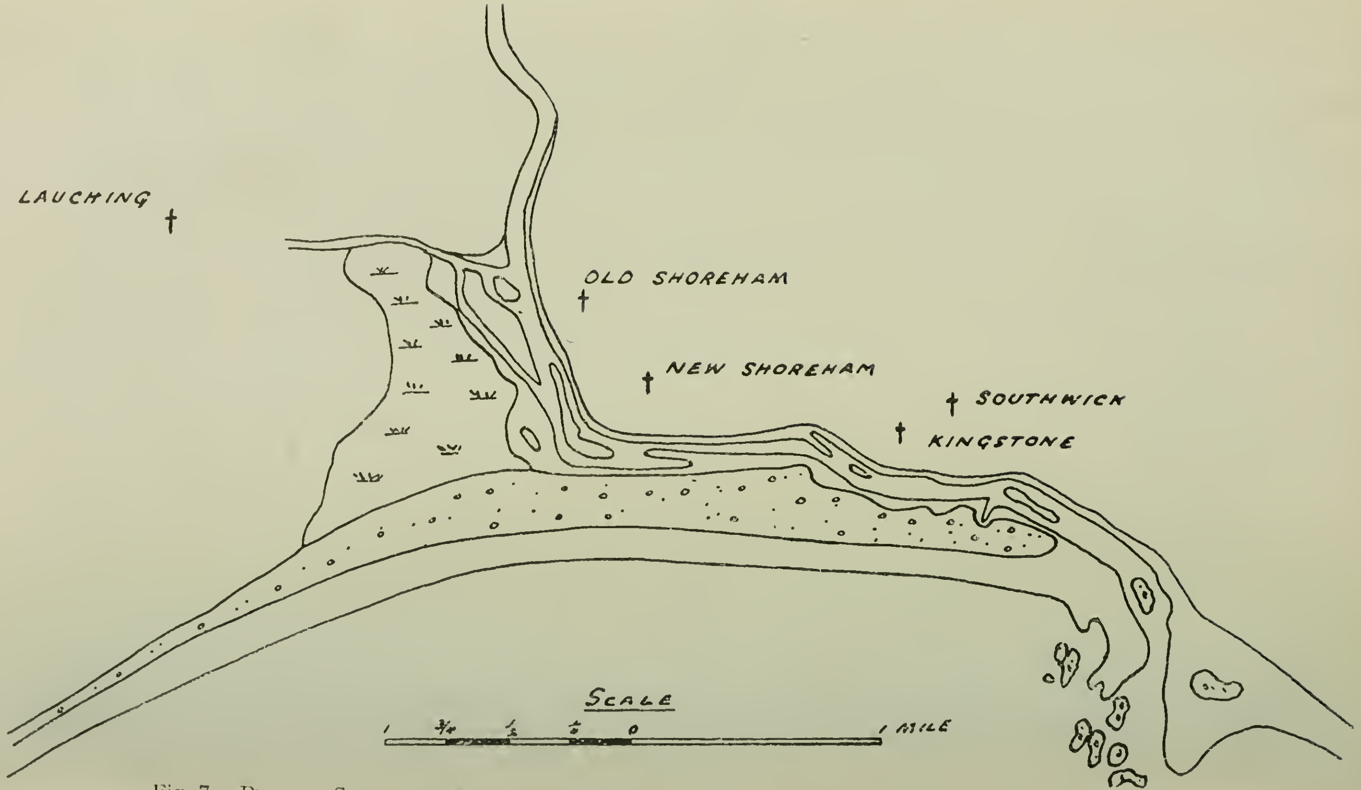


Fig. 7.—Plan of Shoreham Harbour in 1698, from Survey made by Thos. Dumner and Others.

subsequently New Shoreham succeeded Old Shoreham as the port.

There is no doubt that, after the decay of Bramber, Shoreham was a very important harbour. King John landed there with a large army in March, 1199. Towards the end of the 12th century it was a Royal Arsenal, and became one of the principal stations for landing and embarking troops. Between 1205 and 1406 frequent orders were given to Shoreham to supply ships for naval and other purposes. In 1346, 26 ships were built and launched to join the fleet ordered by Edward III. By 1587 the harbour entrance had become much impeded with shingle, shoals and islands.

In a report made for the Royal Navy in 1698 it is stated that "the remains of the ancient Castle of Bramber lyeth about four miles above the town, whence one might take it to have been a port invested with much better circumstances heretofore, now it admits of nothing improveable. The Haven's mouth is a dry Barr upon the Ebbs of Spring Tydes, and the out sea in foul Weather throws up Extraordinary Quantities and heaps of Beach yn manner of small Islands, sometimes here and sometimes there in the very mouth of it. They continue to Build new Ships from 300 Tuns downwards and waiting good season with proper Care they get them into the Sea."

Since the construction of the existing harbour piers the entrance has been much impeded by a shingle bar, which, unless continually dredged away, accumulates up to about 3ft. above low spring tide level. The author has recently made a report on the causes of the formation of this bar and on the work necessary to improve the entrance. The conclusions arrived at were that the prevalent wind waves moved shingle from the adjacent shore round the sea end of the west pier across the harbour mouth, and that the velocity of the ebb currents out of the harbour were not sufficient to prevent it accumulating up to above low spring tide level, and that the only way to prevent the bar forming was to cut off the supply of littoral drift.

There is abundant evidence to show that the steady gain of land which resulted from the formation and reclamation of the salt marshes was sometimes retarded by exceptional storms breaking through the artificial earth embankments or the shingle spit.

A comparison of the survey made in 1292 for Pope Nicholas' taxation and that made in 1340 by the Commissioners appointed to levy the taxes granted by Parliament in King Edward III.'s reign, namely, the ninth lamb, the ninth fleece, and the fifteenth of the goods and chattels of merchants, showed that between 1292 and 1340 a considerable amount of land in the Adur estuary asw inundated. In 1359 a Commission was appointed to repair the sea banks in the parishes of Bramber, Lancing and Shoreham, which had been damaged.

In addition to the occasional inundations owing to the embankments being breached, there is also evidence to show that the shingle spit moved inland at the same rate as the erosion of the adjoining windward coast with which it kept in line.

The author, who has recently made a report, for a number of owners of bungalows built on the spit, as to the causes of the serious erosion now taking place, found that between 1875 and 1913 high water line at the western part of the spit near Lancing had moved inland about 105ft.

CONCLUSIONS.—The space at the author's disposal prohibits the accretion at the other estuary harbours of the south coast being dealt with in detail. In almost every case, however, the sea has built a spit in front of the estuary, leaving only a narrow opening for the tidal water to enter and for the river and tidal waters to discharge. Salt marshes have formed under the shelter of the spit, the area available for shipping being thus continuously decreased, and in many cases the outlets to the sea in their natural state were much impeded with shoals and bars.

In the author's opinion, the chief facts with reference to accretion in estuary harbours of the south coast may be summarised as follows :—

1. Where there is a plentiful supply of littoral drift a spit of shingle or sand is built out from the windward shore across the mouth of the estuary harbour.

2. Salt marshes are formed under the shelter of the spit ; vegetation playing a very important part in collecting the mud and sand brought down by the river, and the sand brought in by the tide.

3. While the prolongation of the spit increases the tidal scour at the outlet, the formation of the salt marshes decreases the scour.

4. That in places where the ebb tidal and river currents are sufficiently powerful to hinder littoral drift, an apposition type of shingle spit is formed on the windward side of the outlet ; erosion occurring on the leeward side.

5. That if the supply of littoral drift is cut off during the process of prolongation of a spit, the end is turned round towards the land, forming a hooked spit.

6. That if the adjoining coast is being eroded, then a narrow spit will be moved inland over the salt marshes at the same rate, keeping more or less in line with the coast.

Discussion.

The **Chairman** (Mr. H. C. H. Shenton) proposed a vote of thanks to Mr. Case for his very excellent paper. The paper was interesting both from an engineering and from an historical point of view. He regretted that there were so few members present to hear it read, but hoped that a good discussion would follow nevertheless.

Professor F. W. Oliver, speaking as a botanist and not as an engineer, thought he could most usefully occupy the time at his disposal by speaking of certain relations between the results which had been or were being obtained by botanists on the shore, and the work of engineers who went out to cause more land to grow where previously there was no land, and to preserve that which was already in existence from the encroachment of the sea. They were really only at the beginning of realising what were the potentialities of the vegetable kingdom. Plants already stood well from an engineering point of view as the providers of materials for construction, but he was sure that in the coming time plants would be called upon to serve the purposes of engineers in their operations on the seashore and also in many other unexpected ways.

Turning to the relation of plants to the phenomena of accretion, he should not say anything of the accretion of blown sand in sand dunes. He did not believe that there was anything new to be said about it. The people of England had never troubled very much about their sand dunes. They had other wealth, and they had never taken their sand dunes seriously. The art of controlling and building up sand dunes by the agency of plants had been perfected by other nations.

As to the accretion of inorganic material, such as particles of sand and mud between tide marks, if there was any property of a plant which was characteristic it was the sedentary property. It must fix itself to a substratum and hold an environment around it. The work of plants on the foreshore, which touched the operations of engineers, was essentially the expression of this sedentary character in the plant. Between tide limits there was a vast assemblage of plants which were doing this very thing in all sorts of different ways. If any sheltered foreshore was examined it was possible to zone it into the domain of very numerous plants, from those which were extremely simple in their construction (algæ) to ordinary higher flowering plants. The only class of denizens of the foreshore which we did not possess in Europe was the mangrove, which was, of course, an arborescent type of shore plant and was the monopoly of the tropical zone. The acclimatisation of mangroves to temperate regions and their employment to form natural groynes was a pleasing vista. For the present, however, Europe had quite enough to go on with.

The humbler forms of plants, namely, the algæ or seaweeds of different kinds which obviously and visibly affected by their presence the mud and smaller inorganic material of the foreshore were included among the filamentous forms and among certain of the brown seaweeds. It would be found that the algæ played their part at different levels, and restricted themselves almost entirely to their own zones. Perhaps the most ubiquitous of all was the Enteromorpha, which was a tube-like green alga. Mr. A. D. Cotton, who had paid great attention to these plants, had discovered that Enteromorpha, like many other algæ, liberated mobile reproductive bodies (zoospores) which came to rest and germinated on particles of sand, which were thus drifted about in great numbers by these flaglike appendages. The discovery might be of greater importance than at first sight appeared.

Some distance below the high-water level of the neaps was a species of Vaucheria, or perhaps a group of species. These Vaucherias mingled themselves with extraordinary intimacy with the mud, so that, in fact, the mud could not be got out of them. They must be regarded as extremely important at the level at which they occurred. At a higher level the same class of work was taken up by a different organism starting below the neap tide high-water mark and going up not quite to that of the springs. This was a curious representative of the blue-green algæ, namely, *Microcoleus Chthonoplastes.* Its name suggested its functions. (The speaker here exhibited a growing specimen of this plant and explained its *modus operandi.*) The alga was always accreting fresh particles, and was of extraordinary importance in relation to accretion. These were just representative forms which he would instance. It was hardly an exaggeration to say that the whole seashore was allocated in zones to different plants which were doing a kind of work of which the engineer would approve.

It was, of course, the business of the botanist to understand the organisms and their relations to their environment, and then, he thought, the botanist's work was done; but it was not his business to keep these facts secret from those persons who were primarily interested in the growth and reclamation of foreshores.

Leaving the algæ, one came to a whole series of salt marsh plants which operated on the foreshore from below the neap tide level up to the high-water mark of spring tides. There were twenty or more so-called halophytes in Britain, some of which were very important as accretors of the soil. Some of these dealt with mud, and others with larger particles, namely, sand. Perhaps it would be interesting if he showed the meeting a few examples of the work of these, and particularly of Salicornia and others which had come under his own observation.

The speaker then exhibited a selection of lantern slides representing varieties of accreting plants and sections of foreshore illustrating the formation of hummocks, and the effect which plants were able to produce on the finer silt and on the coarser drift sand, and thus build them up and raise their level. He then went on to refer to shingle beaches and to the fact that shingle had its plants ; and some of these were able to control in large degree the movement of the shingle. His impression was that there was a very important future from an engineering point of view in connection with the planting of shingle beaches which travelled when they were not wanted to travel, for this class of terrain protected salt marshes, valuable reclaimed marshes, and even foreshore covered with bungalow settlements. Shingle beaches travelled landwards, and would continue so to do unless there was something to arrest them. If the proper plants were present the movement would be arrested and the crest of the beach would be raised. He was perfectly certain that if methods of shingle planting were adopted it would be possible to arrest these movements in a large degree, if not entirely, so that engineers need not have any serious anxiety about them, and the bungalow tenants could sleep peacefully in their beds. There were great possibilities in the introduction of the proper plants in connection with foreshore work, but they would hardly be realised for some time on account of the long time required for study and experiment. One must have direct evidence of the value and importance of every plant before it was applied. It was the business of the botanist to probe this field and place his results, where relevant, at the disposal of engineers who could modify their practice as might be necessary.

Referring more particularly to Mr. Case's paper, he had been very much impressed by several very bold points made by the author. One was the hypothesis of the former shingle spit at Lydd ; another the way in which he explained the bulge on the Pevensey beach at Langard Point and correlated it with other phenomena. With regard to the conclusions summarised at the end of the paper, he confessed that he was in entire agreement with several of them, which he could corroborate from his studies at Blakeney Point. Nothing was more interesting than to try to correlate what was happening in one portion of a tidal system and what was going on elsewhere ; and he was very much interested in the author's handling of that extremely fascinating subject.

Mr. F. J. Gray said that the work of designing and maintaining estuary harbours was beset with one vital difficulty, viz., the reconciliation of the point of view of the engineer with the point of view of the mercantile shipowner. The engineer sought to prevent sedimentation and the nautical man wanted calm water. What the nautical man sought was the original cause of what the engineer endeavoured to prevent. He could not follow the author through the historical part of his paper ; but it occurred to him that he might mention the geological aspect of the matter

They saw around them the bare scoured surfaces of rocks in some places and the broad expanse of alluvial soil in others ; and those were the results of tidal action which had operated for countless ages. Darwin calculated that when the moon was at a quarter of its present distance from the earth the tidal wave had a height of 384 feet ; and taking the solar power also into consideration, he concluded that its total height was 750 ft. When they compared those figures with the present mean height of about 6ft. they could not but realise how important and how stupendous was the part played by the tides in the economy of Nature. It was very fortunate that the author of the paper had not practised as a consulting engineer in those times. At the present day erosion and accumulation were affected by tides probably to only a small degree, because generally the tidal currents had not sufficient velocity to exercise transportation ; and it was the wind or surface waves which were the real mechanical agents.

He had not had any special experience of the phenomena of the estuary harbours on the south coast ; but he had had some experience which was relevant to the general proposition. When he reported to the Holderness Committee on the Estuary of the Humber he found by analysis that the mud on the shore contained constituents which could only have been derived from the erosion of the Holderness coast and the littoral drift southward. The Humber was encumbered with both river-borne detritus and also detritus from the Holderness coast. When he was reporting on the Demerara and Essequibo coast he found, by using a similar method of analysis, that the shores of the estuaries were composed of material that was river-borne. The sand on the shore of the estuary of the Essequibo was much larger than the sand of the " caddy " which was deposited on the sling mud of the seashore. The " caddy " was a fine sand mixed with clay and calcareous matter, and it appeared to be derived by erosion from the land adjacent to the shore. Sling mud was a non-calcareous plastic clay which appeared to be derived from the subsoil clay. Although it was somewhat similar to the subsoil it contained an excess of sand which appeared to be washed out of the " caddy." The table gave the results of analyses of the three materials :—

ANALYSES OF MATERIAL ON THE ESSEQUIBO COAST.

	Subsoil clay.	Sling mud (non-calcareous clay).	"Caddy" fine sand mixed with clay and calcareous matter).
	Per cent.	Per cent.	Per cent.
Sand	27·50	48·68	68·12
Silica	31·12	11·74	5·95
Alumina and ferric oxide . .	28·77	27·44	12·34
Lime	0·11	—	5·07
Magnesia	1·66	1·88	1·18
Carbon anhydride	—	—	3·67
Water, organic matter and loss	10·84	10·26	3·67
	100·00	100·00	100·00

He thought that the analytical method of examining the detritus which was to be found in harbours was an extremely useful one, and one that, with the other usual investigations, would enable the engineer to arrive at conclusions as to what were the conditions and forces which made up the problem before him.

Dr. O. Stapf referred to Mr. Case's remarks on the accretion caused on the south coast by the grass known as *Spartina Townsendii*, or "rice grass." The history of this grass did not date back more than forty years, or, viewed from an economic standpoint, twenty years. The rate and the extent of its spreading were something quite unique, and there was no other plant, whether introduced intentionally or accidentally, which in modern times had gained ground in the same way.

Anyone who went down to Southampton Water, or to Portsmouth, Chichester or Poole Harbour would soon become aware of the presence of extensive mud flats, especially at low tide. There are many thousands of acres of them. Up to the seventies of the last century, or for the most part rather, up to the nineties, they were absolutely bare of plant life save for some lowly and inconspicuous forms of seaweeds. In 1870, however, a grass was found near Hythe, opposite Southampton, which, although at first mistaken for a well-known English species, a few years later turned out to be a new species. No one knew where it had come from, nor, in fact, was its origin known at present with anything like certainty. This grass then grew associated with another *Spartina* which had been introduced into Southampton Water from America early in the last century, and there was a fair amount of it on both sides of Hythe pier. Not much happened to it during the next fifteen or twenty years ; but something unusual must have occurred about the year 1890—perhaps an exceptionally good seeding season, for in the next ten years records of its discovery in widely distant parts, from Chichester in the east to Poole in the west, came in quick succession.

In 1893 a few tufts were observed near Yarmouth in the Isle of Wight, then it turned up at the mouth of Newton River and in Medina River ; two years later we hear of it from Lymington and from Poole, where a single clump was seen in the roadstead near the town. In 1899, 1900, and 1901 it was found in various parts of Chichester Harbour, whilst it had by that time also overrun much ground in Southampton Water. Here a dense belt of considerable width had been formed reaching from one mile above Hythe pier to Calshot Castle. Since then it had covered thousands of acres in other parts of the mudland in the south. To-day in Lymington Bay the triangular area of *Spartina*, including the waterways and so-called " lakes," measured something like two square miles, and extended its arms on one side down to Hurst Castle and on the other to the mouth of Sowley River. In the latter direction it tended to join on to the vast *Spartina* beds at the mouth of Beaulieu River, whence the grass had crept up to within half a mile of Beaulieu village. Here Lord Montague of Beaulieu had watched its amazing growth, which had impressed him so much that in 1907 he had called the attention of the Royal Commission on Coast Erosion to it. In Poole Harbour the rapid spreading was of still more recent date, but the effect had been equally remarkable. Where, in 1908, the clumps of the grass could have been counted and mapped out, they had grown, only three years later, into large continuous patches and belts.

The grass was anchored in the mud by long, vertically descending roots, whilst another system of roots, short and abundantly divided, sprung from the base of the stem and held the surface mud around the tufts, which grew rapidly, forming within a few years large and usually circular clumps, each sending up annually hundreds of leafy stems or culms. Those clumps might finally fuse and thereby form extensive meadows. The grass would grow well in places covered with not more than 3ft. of water at high tide. As, apart from the flower-spikes, it rarely exceeded 2½ft. in height, the greater part of it was regularly submerged at high tide. It was clear that while its roots tended to fix the mud, the stems and the very numerous leaves acted as strainers of the water and accelerated and increased the precipitation of the solid material present, thus gradually raising the level of the flats.

The grass remained green until very late in the season. In the latter part of the winter, however, its stems and leaves decayed, adding not a little to the fertility of the mud and stimulating new growth in the coming season. Once a belt of *Spartina* had established itself on a muddy foreshore it acted like a breakwater, reducing and finally stopping the erosive action of tides, currents or gales; it favoured the silting up of the foreshore, and ultimately its conversion into *terra firma.* As its level was raised to near high-water mark other plants crept into the hitherto pure *Spartina* association, and marsh land was formed. The restriction of the grass to the 3ft. water line at high tide excluded it from all the deeper waterways, and this fact would save them at least for a long time, for as the mud flats were raised, the water that would otherwise spread over them was driven into the channels with greater force, its scouring action was increased, the channels were deepened, and their banks became steeper. This, at least, had been the experience at Lymington.

The effect on animal life on those flats was also important. Previous to the advent of the grass they had been the undisputed home of various kinds of molluscs, which were collected for food, and of eels, which were speared. Where the grass had settled, the molluscs and the eels had gone, the industries which depended on them had been narrowed down more and more from year to year.

The natural spreading of the grass depended mainly on its seeding and the dispersal of the seeds by tides and winds. The seeding was very irregular, but in some years, as in 1911, extraordinary quantities of seeds were produced. Artificially it could be easily propagated by dividing the clumps and planting them in suitable places, the presence of mud and a certain depth of water being necessary conditions. Experiments recently made on a fair scale in the Medway River had been successful in so far as the grass had established itself well and had grown as quickly as in the places from which it was obtained. Specimens have even been taken out to New Zealand, where they throve very well, and there was no reason why it should not do equally well on almost any coast that remained free of ice. Engineers who had to deal with accretion or the protection of coasts ought to take the grass seriously into consideration wherever the conditions were suitable.

Mr. Sidney Rentell said that, as a visitor, he would like to assure the author that he had listened with very great interest to the paper, and particularly the part of it which dealt with the valley and the estuary of the Rother, which he had known for over forty years. He would ask Mr. Case whether he thought, with regard to most river estuaries on the south coast, that a good deal of the trouble had arisen through the deforestation of the old Saxon forest lands of southern England. He thought that

that had a good deal to do with the volume of water going down rivers and affecting the scour at river mouths.

Another question which he wished to ask was whether the author, during his researches into the subject of the Rother marshes and Romney marsh, all of which he (Mr. Rentell) knew, had met with anybody who could point to the site of old Winchelsea. He saw on the map a little black spot marked between Winchelsea and Rye, slightly to the right, and he did not know whether that was meant as marking the site of old Winchelsea or that of Comber Castle with which, he presumed, the author would be well acquainted.

He had lived in Rye from the time that he went there as a little orphan, and he could remember the work carried out there by the late Sir John Coode, of the firm of Coode & Matthews. He remembered the numerous attempts which were made by lengthening the harbour stonework or jetty, to keep the River Rother in bounds and navigable for ships of commercial dimensions, which were general in the days in which he lived there. He could also remember the building of ships up to 400 or 300 tons by Rye shipbuilders ; but they would not dream of using such a size now, because, first of all, they could not launch them, and, secondly, they would have to wait for a very special tide to take them down to the harbour mouth. At the present time they built, fairly considerably, what were called coastal barges.

The following written communications were received :—

Mr. A. Stewart Buckle wrote :—

The subject of Mr. Case's paper is a very interesting one to me as, although I have no professional experience of accretion in this country, it has been brought to my notice very considerably in the course of my professional career in India and the East. It appears to me that erosion and accretion are so intimately bound up together that it is impossible to deal with one without considering the other. The conditions in continents are, of course, very different to those in islands, owing to the rivers being so very much larger, thus causing a great deal more silt to be deposited in a given time. The regular alternations of floods followed by long droughts, such as occur annually in India, also have the effect of making the rivers unstable. Thus changes occur much more rapidly.

I suppose there is in the world no greater instance of accretion than the formation of India itself, for there can be no doubt that the great Plain of India, which stretches from Karachi to Calcutta (about 1,500 miles) and northwards into the Punjab, is nothing but one great accretion formed by the mass of silt brought down from the Himalayas by the rivers of the Punjab and the Ganges. The peninsular part of India, which would, roughly, be everything south of a line drawn from Karachi to Calcutta, must have been an island before this great accretion took place. It is this vast plain that forms the agricultural wealth of India on which the bulk of the rice and wheat is grown.

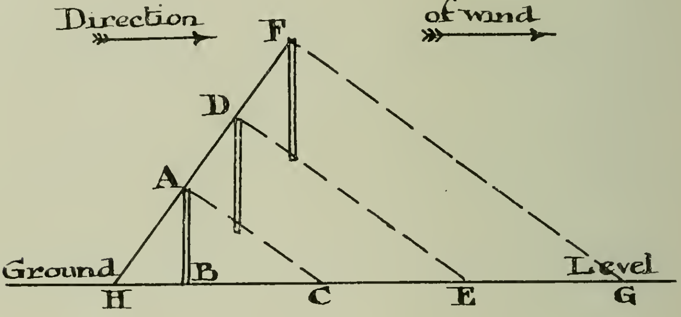
On the eastern side of the Bay of Bengal, within the main estuary of the Ganges and Bramaputra rivers, I once, for a time, had the task of holding on to a railway terminus which jutted right out into the main river, into which a smaller river entered alongside the railway. Seven or eight years before that time, when the railway had been first opened, this terminus had been in a reasonable position on the river bank. It was considered that if we could hold on to our railway terminus by stone pitching until a certain amount of erosion had taken place on an island opposite—one and a half miles away—we should save the situation, and that there would then eventually be a tendency to accretion instead of erosion in our direction.

In Burma I had to bridge a river near its mouth whose estuary in the course of twenty years had eroded 20 miles of coast, measuring in an inland direction, so that a certain town which had been 20 miles inland, had become a coast town in twenty years. A similar accretion had occurred on the opposite bank so that probably no actual land was lost to the country, though it was so to some unfortunate individuals. I must admit that these great changes were chiefly due to a tidal bore acting in conjunction with the river. There is reason to believe that the estuary may eventually swing back again to its old position, so that probably the eventual result will be a general accretion.

Professor Oliver touched lightly upon the question of sand blowing, and mentioned that in this country we were not to any appreciable extent affected by it. That is quite true, but I believe it has been a very serious question in some countries, and is said to have had an enormous effect in many parts of the world. In building a railway across the island of Mannar, on the north-west coast of Ceylon, this sand blowing gave much trouble. In open plains the effect was a scouring out under the sleepers, leaving them partly suspended, just as if the railway had suffered from a flood. This difficulty was got over by keeping the sand well packed up to rail level so that no wind could pass under the rail and between the sleepers, and by encouraging the growth over it of a species of convolvulus which was an indigenous plant, grew very rapidly, and was most effective in holding the sand together. Afterwards the sand blew right over the railway without seriously affecting it. A much more serious matter, however, was the accretion of sand in other places, especially at either end of cuttings. I have known it fill up over the rails as much as 3ft. in a night, exactly like snow drifting. Putting up screens generally had the effect of causing still more accretion on the leeward side, so much so that I often thought that by a proper use of screens the railway embankment could have been made up by utilising the wind. Some temporary benefit, however, could be obtained by placing the screens at proper angles to the wind.

In France I believe they have suffered much from the sand blowing inland from the Bay of Biscay. I understand that it has been finally successfully dealt with in the following manner :—

A screen is erected as at A B. This causes the sand to collect on the leeward side of it until it takes a natural slope as A C. The screen is then removed to D, and afterwards to F, and so on until a hill of any desired height as H F G is built up by the action of wind and sand.



When trees have been grown on the slope F H the effect is to break up the drift and cause the sand to fall back down the slope F H. This is a rough idea only as conveyed to me by one who had studied the subject on the spot.

Mr. Ernest Latham wrote that he thought the author had presented a most useful résumé of fact with regard to the "lost" harbours of the south coast. The chief interest of Mr. Case's paper lay in the historical information given respecting the older marine works on estuaries. Mr. Case, by citing in a definite and concise manner the slow and steady obliteration of estuaries, such as those originally formed by the Rivers Stour, Rother, and Adur, was conveying valuable prophecies as to what might happen elsewhere in the future.

One would have wished for a more detailed explanation of the travel of beach materials under "littoral drift." The evidence given in this respect before the Royal Commission on Coast Erosion, appointed in 1906, was conflicting. From the many existing and divergent opinions he was inclined to accept the views expressed by Dr. Vaughan Cornish in a lecture before the Royal Society of Arts on November 8th, 1912. Dr. Vaughan Cornish advanced the theory that the incidence of tidal rise and fall being normally not synchronous with tidal ebb and flow, the flood tide, therefore, operated over the whole area of the foreshore, whereas the ebb tide washed only the lower half, the scouring effect of the flood tide being greater, Dr. Vaughan Cornish assumes its influence on the direction of beach material to be greater than the influence of the ebb. This influence is, of course, considerably varied by local configuration of the coast line. There is no doubt that "wind-waves" play a considerable part in the movement of shingle, but with shingle, as with sand, there seems little doubt that *general*, apart from *local*, travel is caused by the action of the flood tide, and, therefore, follows its direction.

He was at present retained by a harbour company in South Wales, whose entrance works are situated upon an estuary constantly threatened by the accretion of sand. In recent years one of the adjacent riparian estates had planted clusters of pine trees on the sand dunes in order to arrest progressive erosion by wind and sea. The cultivation of these pine plantations had proved successful from the landowner's point of view, but the sand, no longer able to advance inland under the action of the wind and sea, forms itself into threatening banks outside the harbour entrance. The flood tide set in from the south-west, straight on to the harbour mouth from the Bristol Channel. In December, 1912, a sand spit was thrown right across the harbour mouth. Under his advice regular periodical surveys of the sand accretion were now being undertaken, and definite data with regard to this sand travel were gradually becoming available.

Some four miles further up the same estuary there was another harbour with a considerable volume of shipping, where the authorities are taking the most active steps to save the harbour from obliteration. In 1882 some training works were undertaken here, with a view to holding the river channel close into the harbour mouth. Owing probably to miscalculation of the river discharge, these works proved a failure, and instead of staving off the evil day, had actually assisted Nature in the sanding up of the harbour entrance. Further works, therefore, are now being undertaken, combined with elaborate dredging operations, to keep the port open for shipping.

He was of opinion, however, that both the above harbours were doomed, and would one day form sad parallels with the once flourishing harbours of Hythe and Lymne, in turn providing subjects for research and discussion amongst future generations.

REPLY.

Mr. Case thanked the meeting for the kind reception they had given to his paper. He thought very few points had been raised that needed any reply from him. The speakers had given interesting facts and information with regard to accretion, and especially with reference to the utility of vegetation. He quite agreed with Professor Oliver that the planting of sand dunes had been very much neglected in this country, and he thought that in a great many places they might be cultivated profitably.

With regard to the prevention of the inland movement of shingle spits by planting, he might mention that at Shoreham Harbour about thirty years ago a hedge of tamarisk was planted on the shingle spit for the purpose of preventing it from being moved inland. Since the hedge had been there it had no doubt to a large extent prevented the shingle from being moved inland over the salt marshes. Referring to the use of vegetation for this purpose, he thought that, while the vegetation would be very useful above high-water mark for stopping the inland drift of shingle owing to exceptional storms, it was essential that the shore between high and low-water mark should at the same time be properly groyned to prevent littoral drift.

He agreed with Mr. Gray that the tidal currents as a rule were ineffective in transporting shingle, and that it was mainly moved by wind and waves.

As to Mr. Rentell's inquiry, the black spot on the map to which he referred was meant to be Camber Castle, and the exact site of old Winchelsea was very doubtful, and various historical writers gave different places for it. It was very possible that the cutting down of forests in Kent and Sussex affected the amount of water flowing out of the estuary harbour, but he could not speak with much weight on that subject.

1*st December*, 1913.

ARTHUR VALON, M.INST.C.E., PRESIDENT,
IN THE CHAIR.

THE CORROSION AND RUSTING OF IRON.

By ERIC K. RIDEAL, Ph.D., M.A.

> "The rusting of iron has received its usual amount of study and controversy, but the question remains as ragged and dubious as it has been for years."—*The Engineer*, January 12th, 1912, page 30.

IN this age of scientific ingenuity one is prepared to accept anything that comes out of the mouth of an expert. If, for instance, we were informed that it was quite possible to make bricks without straw we might be prepared to accept this statement, in spite of historic evidence to the contrary. Under no circumstances, however, might we be expected to believe that engineers can dispense with the metal iron, for although the non-ferrous alloys may in the distant future terminate the reign of this all-important metal, it must be confessed that the time is not yet.

It is a well-known characteristic of human beings that the commoner and more intimate things of this life have been more deeply investigated, but at the same time are less understood than those that are more distant. This holds true to a great extent in the case of the corrosion and rusting or iron. Time after time has the convenient verdict "structural failure" been brought by an intelligent jury when investigating the "death" of, say, a water pipe, a suspension bridge, or a girder roof, although no evidence of the actual cause of the disaster may have been forthcoming. A small number of these failures may be attributed to inaccuracy in mathematical calculations; again, we may reasonably expect steel, when subjected to more or less systematic periodic vibrations, *e.g.*, on locomotive trucks or motor cars, occasionally to develop lines of intercrystalline weakness and fracture, but undoubtedly one of the most prolific causes of accident is attack by rusting and corrosion.

The microphotograph kindly taken by Mr. E. Law is a section of a tie-rod that failed in Charing Cross railway station. The situation was one very conducive to corrosion, since the moisture deposited on the cold surfaces of the metal was highly charged with the sulphur acids of burning coal. It will be seen that practically three-quarters of the metal has been corroded away, owing to the absence of a suitable protective surface.

Although the phenomenon of rusting has been observed and noted from times immemorial, it is only comparatively recently

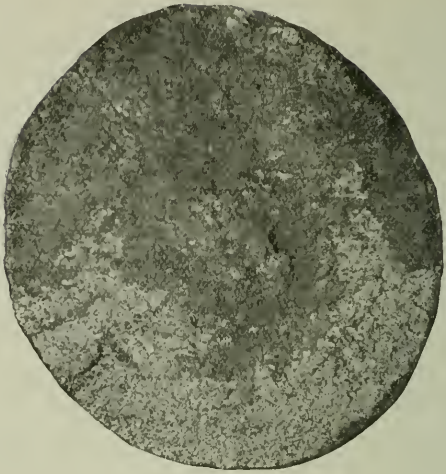


FIG. 1.

that a systematic investigation of the various factors that go to make up the process has been attempted. Chemically, rust is of very complex and variable composition, consisting of hydrated oxides of iron, basic ferric carbonate, organic matter, and frequently fixed sulphur, phosphates and silicates.

Many theories have been advanced to explain the mechanism of iron corrosion, and in the author's opinion at least, the so-called electrolytic theory advanced in America by Whitney, Cushman and Whipple, and in England by Tilden, Walker and Lambert and others, is by far the most convincing. We may regard all metals as exhibiting definite tendencies to go into solution even in pure water. The magnitude of this " solution-tendency " depends on two factors (i.) the nature of the metal—zinc, for example, possesses a very high, and platinum a very low solution-tendency, and (ii.) the composition of the solvent, *e.g.*, copper possesses a high solution-tendency in ammoniacal solutions and a low one in copper sulphate. During the process of solution the metal becomes electrically charged, and the dissolved portion (in the form of hydrated metallic " ions ") takes on an equal and opposite charge. An electrical balance is soon arrived at, and solution ceases unless there is some extraneous mechanism to prevent equilbrium being attained. This disturbance of equilibrium may be accomplished by the formation of numberless minute electrolytic cells all over the surface of the metallic plate. Each cell consists essentailly of two contiguous metals of different electrolytic solution-tendency immersed in the same electrolyte.

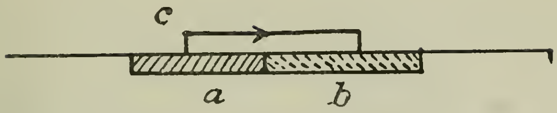


FIG. 2.

a b. Metals of different electrolytic solution-tendencies.
c. Electrolyte in contact with the metals.

By this means a complete electrical circuit is formed, and one electrode can continue to corrode, while at the other an equivalent amount of some other metal (or hydrogen) possessing a lower solution-tendency than the dissolving metal is deposited. It will be noticed that this theory demands for the condition of rust formation (i.) the presence of contiguous conducting particles or nuclei of different electrolytic solution-tendencies; (ii.) contact with an electrolyte.

In the case of pure electrolytic iron there are no nuclei of solution-tendencies different from that of the rest of the metal, and if it were not for the fact that iron possesses a crystalline structure, electrolytic iron would not rust when immersed in tap water. Although the corrodibility of pure electrolytic iron is at present in dispute, it is evident, as a logical consequence of the electrolytic theory, that unless the iron crystals are similarly orientated at the surface, a minute difference in solution-tendency will be found between crystals possessing dissimilar exposed surfaces. Provided there are in the tap water no metals of solution-tendencies less than that of iron, hydrogen will be liberated at the iron surface. This film of hydrogen exerts a considerable insulating action on the iron. The difference of solution-tendencies between the crystalline electrodes is rarely great enough to permit the electromotive force of the corrosion cell to rise to that critical value where hydrogen is liberated in the form of gas; the small cell consequently becomes "polarised," and corrosion ceases. Unless there is some alternative mechanism for the removal of hydrogen, even impure iron or steel will not rust. Generally atmospheric oxygen accomplishes this by direct combination with the hydrogen; the rate of combination of the two gases consequently governs the rate of corrosion (unless, as has been mentioned above, another depolariser is present); this is a matter of some importance when the question of preservation of ironwork is raised. Ordinary cast or wrought iron and steels contain many small nuclei of foreign matters, *e.g.*, carbides of iron, graphite, traces of metals such as manganese, metallic conducting bodies, such as slag inclusions, also silicon, phosphorus, and allotropic modifications of the iron itself. These are capable of acting as the electrodes of small corrosion cells set up over the surface of the metal, hydrogen is liberated, and some depolariser permits the cell to continue working. In the light of this theory we can now briefly survey cases where corrosion is met with in practice, and at the same time examine the utility (or, as the case may be, the futility) of the methods in vogue for checking that corrosion.

Rusting in Ferro-concrete.—The corrosion of steel girders encased in concrete is somewhat rare, but examples are met with occasionally. It is found in these case that the concrete is not waterproof and is generally deficient in lime. The following explanation serves to indicate the mechanism of corrosion in the light of the electrolytic theory. Since concrete conducts electrically when the pores are full of water, the surfaces of the steel comes in contact with an electrolyte; small corrosion cells are set up on the surface of the impure steel; the liberated hydrogen is removed by aerial oxygen, the rate of combination with which is greatly accelerated by the catalytic effect of the rough concrete surface. When the cells continue to work, a slight thermal effect causes the small cracks in the concrete to open up and permit the ingress of more water.

The fact that ferro-concrete corrosion is not more prevalent can be explained as follows:—It is well known that several metals, notably iron and nickel, when made the anode of an electrolytic cell in an alkaline electrolyte, become "passive," that is, they no longer exhibit a tendency to go into solution, and appear to possess an abnormally low electrolytic solution-pressure. This phenomenon has been recently dealt with at the Faraday Society, and the author would refer those interested to the Transactions of that body. Concrete contains lime, and frequently traces of stronger alkalies; these dissolve in the percolating water, and cause it to become distinctly alkaline, the anodes of the corrosion cells become passive, the current ceases, and the steel does not rust.

As protective agencies against ferro-concrete corrosion various forms of soaps and oils have been suggested. These render the concrete waterproof, and thus prevent the formation of rust cells. A dense cement rich in lime is, as we have seen, the most suitable material for embedding steel work. This is a typical example of rusting brought about by self-generated *electrical corrosion.* A very frequent course of corrosion is from *externally derived currents.*

The insulating coverings of electric light leads, telephone cables and even electric bell wires, when damp, become conducting, and are a source of stray currents which may use any neighbouring iron girder or pipe as a part of the electric circuit, with the result that corrosion sets in. The earthed return rails of trams, unless there is no drop of potential along them (a state of affairs unattainable in practice), are a common source of these

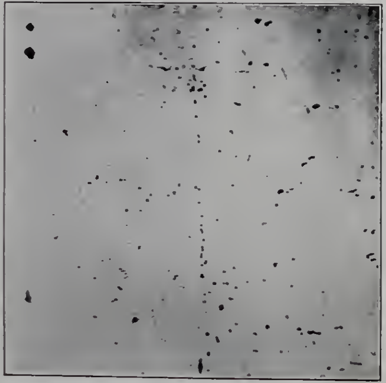


Fig. 3.

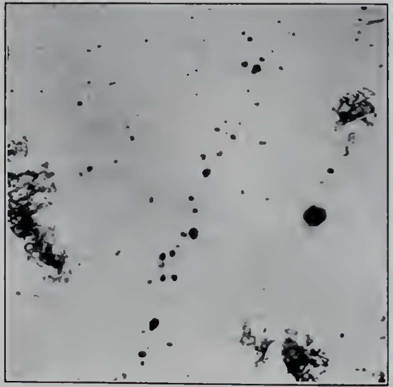


Fig. 4.

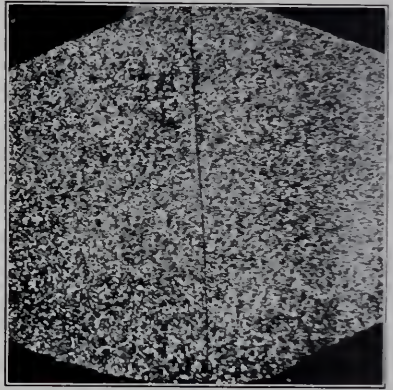


Fig. 5.

Microphotographs shewing effect of Welding.

strong currents, and corrosion of neighbouring ironwork is practically certain. To minimise the effect, the pipes or steel girders must be either (i.) sufficiently insulated from the wet soil by means of a protective coating or insertion in dry cement or brickwork, or (ii.) connected to the rails at frequent intervals, thus causing the whole network to be at one potential.

The following table shows the permissible loss of voltage on the tram rails in some large European cities (*Engineering Record*, 1909) :—

Town.	Permissible potential loss on return circuit.	Potential observed between rails and pipes laid near.
	Volts.	Volts.
London	7	+1·4 pipe −4·2
Paris	1 per kilometre 5	7
Berlin	No regulations	1
Vienna	5–7	—
St. Petersburg	1·5 in towns	—
Moscow	3 in suburbs	—
Glasgow	7	1
Liverpool	7	45
Christiana..	10	5

Other cases where externally supplied currents cause corrosion are to be found at the junction of dissimilar metals, such as brass and iron, copper and iron, and even cast iron and wrought iron or iron and steel, these being in reality magnified examples of corrosion cells. Difference in stresses, porosity, or previous history may cause iron, otherwise uniform in composition and behaviour, to possess different electrolytic solution-tendencies. In hot water pipes of a circulating system slight electrolysis between the hot and the cold portions does undoubtedly occur.

Fig. 3, from a microphotograph taken by Mr. Law shews the effect of welding on the corrosion of a piece of iron. It will be noticed that the line of weld is just observable along the metal, its presence being indicated by the small spots of oxide at the junction. In Fig. 4, which is magnified 1,000 diameters, the course is still more easily followed. The truly startling result of exposure for a short time to acid corrosion is shewn in Fig. 5, the magnification in this case being only two diameters.

Not only is the iron corroded away by these currents, but at the same time the surrounding iron, although unaltered in shape, is converted into a soft and spongy form unsuitable for any structural work. The nature and composition of this modified iron (considered by some to be an allotrope) is still unknown. It has however, been shown that it contains both phosphated and silicates, probably indicating that selective oxidation of the impurities in the iron (Si and P) has been brought about by the electric current.

Corrosion in Water Pipes.—Water pipes are in the unfortunate position of being exposed to both internal and external attack. The factors that govern the rate of attack on each side are different in character, owing to the difference in the natures of the electrolytes in which the surfaces are immersed. The material for pipes depends on the size ; for small pipes cast or even wrought iron is very suitable, but as the diameter gets larger, stronger, thinner, and consequently proportionally lighter, pipes may be constructed in steel. The thinness of steel pipes has often been cited as a disadvantage of this material, for it is clear that if corrosion once sets in, bursting would occur. The investigation of the rate of corrosion in water pipes laid in the ground is difficult, since they can neither be inspected nor repaired unless the ground is opened up. The practice of laying them with gas and electric mains in a common tunnel would seem worthy of greater support than it receives at present.

Surface waters containing relatively large amounts of carbon dioxide and oxygen rapidly corrode iron work, while rusting is accentuated if the water is very soft. Many cases are on record where such waters have in a few months corroded over three-fourths of the effective cross-section of a pipe. Small quantities of lime when added to such waters precipitate a thin protective film of calcium carbonate on the metal. This film is a very useful antidote to corrosion, and its value has for a long time been overlooked. In a recent report by the Corrosion Committee of the Institute of Metals Dr. Benbough has noticed cases in which the film has been so thin as to be translucent and yet has produced a completely protective effect. Drainage water containing, in addition to carbon dioxide and dissolved oxygen, hydrogen sulphide, chlorides (*e.g.*, sea water), nitrites and nitrates and ammonia, all readily attack iron pipes.

The effect of the iron hydroxide, basic carbonate and occasionally sulphide which are deposited by the process of rusting in the small corrosion cells is to accentuate corrosion, since, unfortunately, these salts of iron act as nuclei having solution-tendencies different from the rest of the iron. This phenomenon, namely that rust is a conductor of electricity, behaving as a metal having a more or less definite electrolytic solution-tendency, thus making it suitable as an electrode in a corrosion cell, explains the well-known fact that if rusting has once commenced it is useless to apply any paint or other protective material until every scrap of rust has been removed.

Another deduction that is also more or less borne out by experience may be made, viz., when rusting has once commenced the subsequent rate of corrosion does not depend on the composition of the original iron or steel. It is only after a considerable period has elapsed that the rust surface will become relatively so big, and the attacked iron surface so small, that it may be said that the rust protects the ironwork. Certain waters, however, which contain a great deal of colloidal organic matter, *e.g.*, marshy waters, containing the sphagnum acids, deposit their colloidal contents on the rust and cause a protective film to be formed over the whole of the ironwork, protecting it for a great number of years.

When steel pipes are used, the phenomenon of "pitting" sometimes occurs. In these cases the metal corrodes in spots. This subject has been investigated by G. and M. Whipple, who have come to the conclusion that pitting is due to the presence of mill scale. Mill scale is composed largely of iron oxides containing a little slag, and, as indicated above, oxides and hydroxides of iron are capable of acting as elemental electrodes for the corrosion cells ; the presence of a small piece of scale would, consequently, be expected to produce a local corrosion cell of some magnitude and cause the pitting. G. and M. Whipple found that the magnetic oxide of iron was more active in this respect than the red rust (Fe_2O_3). Steelwork completely covered with scale would not be very liable to attack. since the surface would be fairly uniform. It is only when part of the scale has been removed mechanically, exposing the steel surface underneath, that corrosion proceeds with some speed ; the remedy against pitting is clearly to remove all the mill scale before use.

Quite recently in my father's laboratory an interesting case of external corrosion was investigated. In a well known club the hot water pipes had been laid in terrazo paving, the heat of the pipes acted on the magnesium oxychloride of the cement, liberating hydrochloric acid. The liberated acid acting on the metal in a confined space necessitated the removal of the pipes a very short time after being laid.

The Protection of Ironwork.—Cushman gives an interesting list of the various means of protection adopted for preserving different kinds of iron and steelwork :—

Coating.	Material used for.
Zinc, tin, copper, lead, nickel	Roofing and sheathing of buildings, wire for telegraph, fencing, suspension cables. Nails, screws, bolts and fittings. Tanks, vessels and utensils, chains, pipes and tubes for special purposes.
Paints, varnishes, bitumens, cements	Structural iron and steel, decorative ironwork fire escapes, locomotives and cars. Smoke stacks, gas and oil tanks, pipes. Machinery in part, boats and ships, boilers on the outside, trolley poles, masts, posts, mailboxes.
Lacquers, varnishes, japans and enamels.	Small articles, hardware utensils, implements, tools and cans.
Processed after manufacture to form a skin of oxide, phosphide, or some other compound.	Structural steel, gun-barrels.
Usually unprotected . .	Machinery in part, tools and farming instruments, chains, boilers and tanks inside. Railroad rails, plates and bolts.

From the point of view of the electrolytic theory, the protection of ironwork from rust resolves itself into the problem of preventing the corrosion cells from working. The unit cell, as we have seen, consists of three essential parts, two contiguous, electro-chemically dissimilar, metallic particles with their surface exposed to a common electrolyte. In order to prevent current from flowing and thus stop the operation of rusting, we may adopt any of the following methods :—

I. *Elimination of Dissimilar Electrodes.*—The passivity of iron in the presence of alkaline electrolytes has already been alluded to. Any other method of making the iron surface homogeneous instead of relatively heterogeneous will eliminate the variations in solution-tendency observed over the surface of an iron liable to rusting. Immersing the sheet of iron in a strongly oxidising solution, such as chromic acid, brings about the oxidation and elimination of the various impurities, leaving a homogeneous surface of nearly pure iron ; the same result is obtainable by electro-plating impure iron with a film of the pure metal ; this method of protection has been recently adopted for use on a large scale.

Galvanising iron by dipping it in, or electro-plating it with pure zinc is one of the oldest methods of bringing about uniformity of surface. Zinc possesses one great advantage—it will form a solid solution with iron ; thus dipping iron into zinc ensures a perfectly uniform skin. A metal like tin, which contracts when applied to an iron surface, thus exposing part of the underlying metal, is clearly unsuitable for this purpose. An attack on galvanised iron has been started recently, it being said that the use of galvanised iron is both dangerous and useless for a potable water. It is true that zinc salts, when taken internally, are toxic in character, and although the doses would be nearly infinitesimal, symptoms of ill-health would probably follow. Furthermore, the solution-tendency of zinc is greater than that of iron. As a matter of general practice the coating of zinc on a galvanised pipe is so good that the surface is practically homogeneous, and even if small impurities in the zinc itself produced corrosion cells in the metal, a protective film of oxide and carbonate of zinc is very quickly formed.

The author, with Mr. Evans, investigated this point by passing tapwater through a clean zinc tube down the axis of which was fixed a copper rod. The amount of corrosion of the zinc was determined by connecting rod and tube to a milliampere-meter ; after less than two hours passage of the water, the amount of solution taking place (as measured by Faraday's method) was imperceptible, the zinc being already protected.* The attack on galvanised iron is therefore perfectly unjustifiable unless the iron is not really properly coated with zinc, when, of course, rapid corrosion and solution of this metal will take place. This fact is so well known that the practice of fixing galvanised iron with iron nails is now obsolete. The Sheradizing process may also be included in this category. The blowing of superheated steam on to the surface of hot iron is another method that has been adopted in practice for producing a uniform skin ; in this case the film consists of a homogeneous oxide of iron.

II. *Raising the Resistance of the Electrolyte.*—We have noticed that the current has to flow through the electrolyte in which the iron is immersed. By raising the specific resistance of this part of the circuit the current flowing in each elemental cell will be decreased and the corrosion correspondingly lessened. One of the best rust-preventers consists of a mixture of tar and hydrocarbon oil applied to the cleaned and heated surfaces of the metal. An adherent waterproof film of badly conducting tarry matter is thus obtained. Its effectiveness is so well known as not to to require mentioning in detail. Paints, notably those containing red oxide of iron, act in a similar manner, but as has been shown by Liebrich and Spitzer, the paint particles themselves may act as electrodes, provided small quantities of water are present. They give the following details as regards the magnitudes of the potential differences set up by the pigment particles in contact with an electrolyte on the surface of a piece of iron.

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* It has been noticed that when hydrogen happens to be liberated and is not removed by a depolariser, it acts as a cushion interposing an almost infinite resistance in the circuits of the corrosion cells, thus bringing the capabilities for work almost to a standstill. It so happens that iron and especially zinc possess a considerable over-potential for hydrogen : this fact effects corrosion in so far that differences in the electrolytic solution-tendency of two neighbouring nuclei must be considerably greater to cause the actual liberation ot hydrogen than is required to cause its formation. If hydrogen were liberated in the form of bubbles, corrosion would naturally continue, but if only formed on the surface of the metal, rusting ceases. The conditions of hydrogen liberation rarely obtain in commercial irons, whether galvanised or not.

E.M.F's. of various cells.

$ZnO/KCl.\ H_2SO_4/Fe$	20°C.+0·150 volts.
$PbCO_3/KCl.\ H_2SO_4/Fe.$	20°C.+0·095 volts.
$Pb_3\ O_4/KCl.\ H_2SO_4/Fe.$	20°C.+0·75 volts.
$Fe_2\ O_3/KCl.\ H_2SO_4/Fe.$	20°C.+0·090 volts.

Specific resistances of pigmentary materials—

Zinc oxide	$0{\cdot}34 \times 10^{13}$ Ohms.
Lead carbonate ..	$0{\cdot}41 \times 10^{13}$ Ohms.
Lead oxide	$0{\cdot}39 \times 10^{13}$ Ohms.
Iron oxide	$0{\cdot}16 \times 10^{14}$ to $1{\cdot}04\ 10^{6}$ Ohms.

Generally, paints are not quite waterproof, and frequently, in the process of drying out oxidation of the organic oil present actually generates water *in situ*: under these conditions corrosion may be actually augmented by the application of thick coatings of paint. Suitable paints should possess high specific resistances, great adhesive powers and tenacity, a thermal dilation-coefficient approximating to that of iron, and a minimum amount of included moisture or easily oxidisable matter containing hydrogen. Cushman divides pigments into three classes :

(1). Inhibitors.
(2). Indeterminates.
(3). Stimulators.

INHIBITORS.	INDETERMINATES.	STIMULATORS.
Zinc, lead chromate.	White lead, basic carbonate.	Lampblack.
		Ppt. Barium sulphate.
Zinc oxide.	Sublimed lead, basic sulphate.	Ochre.
		Bright red oxide.
Zinc chromate.	Sublimed white lead.	Carbon black.
Zinc barium chromate.	Lithopone.	Graphite.
Zinc, lead white.	Orange mineral.	Barium sulphate.
Prussian blue.	Red lead.	Chinese blue.
Chrome green.	Litharge.	
White lead.	Venetian lead.	
Ultramarine blue.	Calcium carbonate.	
Willow charcoal.	Calcium sulphate.	
	China clay.	

It is interesting to note that the chromates all come within the first category, doubtless owing to the " passifying action " of these salts.

The above table disregards one of the most important factors in paint protection, namely the nature of the vehicle in which the pigmentary particles are suspended. Friend, who has investigated the subject very carefully has shewn that linseed oil when used as the pigmentary vehicle undergoes prolonged atmospheric oxidation.

He likewise showed that films of the linoxyn, the oxidised product of linseed oil, were distinctly permeable to water vapour.

PERMEABILITY TO WATER VAPOUR.

Time in days.	Increase in weight of flasks containing dry calcium chloride, and closed with films of linoxyn.		
	With 0% wax added.	With 0·5% wax added.	With 1·0% wax added.
2	0·47	0·29	0·30
4	0·86	0·54	0·56
6	1·23	0·77	0·81
8	1·54	1·03	1·07
10	2·00	1·29	1·34

Slade suggests the following procedure as a test for the porosity of paints to water. An iron spiral coated with a film of paint is made the cathode in an electrolytic cell, the rate of increase of current through the cell is a measure of the porosity of the paint film to the electrolyte. I have obtained comparable results by making use of a very simple apparatus in which no external source of current is necessary. The paint tester consists of a modified Daniell cell, in which the zinc rod is replaced by an iron plate or rod coated with the paint to be tested, the electrolyte consists of normal sulphuric acid. This is contained in a porous pot, the other electrode is as usual a sheet of copper in copper sulphate. As in Slade's apparatus the rate of increase of current is a measure of the porosity of the paint. It is free from the disturbances that might be caused by polarisation or passivity.

III. *Protection by means of Metals.*—The electrolytic theory of corrosion is based on the assumption that nuclei having a low solution-tendency permit the passage of iron of relatively higher solution-pressure into solution. It is clear that if this assumption be correct, metals of still higher solution-tendencies (those more electro-positive than iron) should by their own solution be capable of protecting iron.

For practical purposes it is of purely secondary importance how much greater than that of iron the solution-pressure of the protector should be, provided it makes a good electrical contact with it, since the theoretical value, depending as it does on a variety of factors, such as the conductivity of the water, the over-potential of the iron, as well as its age and temperature, and, again, the relative areas of the iron and the protector metal, makes its determination a matter of great difficulty.

Zinc (a metal of high solution-tendency) has been used since the time of Sir H. Davy, and has been found to be the most suitable. It has been advised to use 1 sq. ft. of zinc to every 50 sq. ft. of iron surface, and then to diminish to 1 sq. ft. per 100 sq. ft. of surface. The action of this protector metal must not be confused with its action as a protective covering, for in the case of galvanised iron neither iron nor zinc go into solution, but in this case the latter metal is continually dissolving and liberating hydrogen at the iron surface.

We have alluded to the coating of zinc oxide which is rapidly formed when the bright metal is immersed in water. This film does not form so readily when the zinc is going into solution, nevertheless, filming does occasionally take place, with a consequent increase in the corrosion of the iron. Alloys of aluminium have been suggested as a substitute to obviate this difficulty.

IV. *Protection by externally applied Currents.*—This method of protecting boiler tubes from corrosion appears likely to become of great practical importance in the near future. The process consists essentially in artificially lowering the solution-tendency of the iron by means of an imposed electric current. The iron, acting as an anode of the corrosion cell, tends to go into solution, but is prevented from doing so by being made the cathode of an artificial cell driven by an external source of current, such as a dynamo or set of accumulators. As anode of the artificial cell either a soluble electrode like iron or an insoluble one like carbon may be used. Harker and McNamara, at Sydney, Australia, and Stanton Clement and Walker, at Pittsburg, U.S.A., have pointed out, and experiments carried out at the Manchester School of Technology have demonstrated, that the quantity of currents required to prevent corrosion is usually very small, and can be determined from the actual loss on corrosion. The most suitable current-density under normal conditions is said to be about 0·1 ampere per sq. ft. The practical difficulty of insulating the anodes of the artificial cells from the rest of the iron seems to be overcome.

The foregoing brief summary of the influences at work and of the methods of checking corrosion serve to show that the so-called electrolytic theory is perfectly in accordance with observed facts, and that it offers reasonable explanations for the somewhat complex and sometimes mystifying phenomena that are occasionally to be noted.

Testing Iron and Steel for Corrodibility.—The constructional engineer who is interested in the question of corrosion from the practical standpoint must have some means at his disposal for testing the suitability of different kinds of iron and steel, and also the efficiency of the various processes of painting, plating, or otherwise treating metals which may be offered to him. As far as systematic testing is concerned this, having regard to our present state of knowledge on the subject, is out of the question.

It is absolutely necessary to govern and study local conditions, for not only is it practically impossible to reproduce the natural condition of aëration, dilution, changes in electrolyte composition, light and darkness, slight mechanical abrasive actions of sand, etc., and other more or less accidental disturbances that obtain in practice, but a further difficulty is met with in sampling the iron or steel for testing purposes. Small pieces suitable for careful investigation usually yield data that are in no way comparable to the actual results obtained in the body of the iron or steel itself. The oldest method in vogue is the immersion test.

Strips of the metal are carefully cleaned and weighed, and are placed in samples of water, or exposed to similar atmospheric conditions as will be met with in practice (*e.g.*, in air for outdoor construction ; in fumes of chemicals for steel that is to be used in industrial constructional work). After a long period of exposure the samples are taken out, carefully scrubbed with a brush, dried, and weighed. The loss of weight per unit surface per unit time is the corrosion factor.

In addition to the above-mentioned objections of impossibility of suitable sampling and inability to reproduce natural environments, the method possesses two great disadvantages.

(1) It is very slow ; accelerated corrosion tests, such as immersion in 20% sulphuric acid or in 7·5% sodium chloride, or, again, in 1% ammonium nitrate solutions, have been proposed and attempted, but it is found that the corrosion factors do not, as a rule, bear any relationship to those where the conditions of nature are at least being partly reproduced.

(2) As we have noticed, corrosion may be either superficial or in the nature of pitting. It is obvious that a " pit " is more deleterious to strength—the important factor in constructional work —than an equivalent amount of superficial rusting. The process

above described makes no differentiation between them. A further source of discord between the factors of various investigators is caused by the nature of the preliminary cleaning that the metal surface is subjected to.

G. and M. Whipple introduced an electrolytic test for corrosion in which the rate of solution was accelerated by making the test piece of metal the anode of a cell driven by current from some external source. They obtained the following results in one of their tests :—

Material.	Volts.	Current in milliamperes.	Loss of weight in gms.per sq.cm.	Time.
Steel	2	2·8	0·013	22 days.
American ingot iron ..	2	2·0	0·015	
Wrought iron	2	2·0	0·017	

This form of test brings out the " pittings " on the surface of the metal with great distinctness, and serves as a method for indicating the nature of the corrosion.

Another electrolytic test devised by H. Hanson and W. Lewis for determining the mutual corrosive effect of two metals consists in connecting electrodes of the two metals through an amperemeter, keeping the solution about the electro-negative metal saturated with air, and measuring the current in the external current. Provided some standard metal to form the one electrode could be agreed upon, this method, which eliminates the necessity for the external current required in Whipple's test, is a great simplification of electrolytic corrosion processes.

There is one other method of testing corrodibility also devised by G. and M. Whipple. This may be defined as an electrical survey method. By means of a sensitive galvanometer and a travelling contact pole of copper wire, the other terminal being connected permanently to the plate of metal, the magnitude of the current flowing through the galvanometer, when contact is made on to the surface of the metal, is determined. Uniformity of surface currents is taken to indicate low corrosive tendencies, while alterations of any magnitude are associated with a tendency to rust. The value of the method seems to be somewhat vitiated by the presence of the metallic travelling touch electrode, which must undoubtedly both affect passivity and set up local currents not necessarily of constant magnitude.

The author would suggest that the plotting of potential fall between the surface of the metal and the solution in which it is immersed, by the aid of an auxiliary electrode (the calomel or hydrogen type), would give figures equally significant in value and free from the disadvantage alluded to above. It must, however, be recollected that, according to theory, the rate of corrosion is determined solely by the magnitude of the local currents, and that determinations of E.M.F. are only of value in so far that they indicate solution-tendency and not the rate of rusting.

The influence of small quantities of different elements on the corrodibility of iron has been investigated in great detail ; but owing both to lack of uniformity among the methods of testing and to our experience as to the nature of really pure iron, conflicting statements are frequently met with. The following classification may be taken as a summary of the preliminary work on this subject, carried out by various experimenters, notably Burgess and Aston, Friend, Cushman, and others :—

Elements causing increased corrodibility.	Elements that do not cause marked changes in corrodibility.	Elements causing slight decrease in corrodibility.	Elements causing marked decrease in corrodibility.
Manganese	Aluminium	Lead	Copper
Selenium	Arsenic	Cobalt	Nickel
Silicon	Silver	Tin	Chromium
Sulphur	Tungsten	—	—

The Influence of Carbon.—The physical and chemical changes caused by the addition of small quantities of carbon to pure iron are so marked and varied, and the components of the iron-carbon series are so many in number, that investigation of the factors governing corrosion in cast and wrought iron and simple steels is a matter of the greatest difficulty. The problem is further complicated in practice by the unavoidable presence of traces of other elements, *e.g.*, manganese, phosphorus and silicon, while for other reasons the addition of elements, such as nickel, chromium, or tungsten is advisable. Corrodibility, like the other physical characteristics, is greatly influenced, as has already been mentioned, by the treatment to which the iron-carbon mixtures may have been subjected.

In the case of steel Chappell has shown—(i.) In rolled and annealed steels corrodibility rises with the carbon content to a maximum at the saturation point (0·82%), and falls with further increase of carbon ; (ii.) in quenched and tempered steels a continuous rise in corrodibility occurs, no maximum being found.

The investigation of the nature of those nuclei that are liable to cause alterations in the surface-potential of commercial irons and steels is at the present time being carried on by numerous investigators, but the tabulation or survey of the data at our disposal is far beyond the scope of this paper.

There is one point, however, that might be mentioned; analyses by themselves are liable to be very misleading, for from the composition of a piece of iron or steel alone practically no data as regards its corrodibility can be drawn. It is essential to have information, not only on the percentage composition of the material but also on the distribution of the components in the metal. As an example of this factor the influence of oxygen in iron or steel might be cited. The analyses determine the total amount of this element in the sample of the metal, but they give no information as to whether the oxide is present in the form of rust forming nuclei or in the form of a thin homogeneous film on the surface of the metal, which of course may efficiently protect the metal against all attack.

The following are some of the most important factors among those which determine nuclei formation. In the case of binary alloys the components may form a continuous series of solid solutions ; the magnitude of the electrodes of the individual corrosion cells is very small for atomic or molecular dimensions, and corrosion, if it does occur, will be perfectly uniform and free from pitting. The components may form conglomerates either in the process of manufacture or due to segregation in the solid state (*e.g.*, manganese sulphide in certain steels). Generally the potential distribution on the surface will be non-uniform in character, and rapid corrosion, accompanied by pitting, may be expected.

Either one or both of the components may be present in the form of allotropic modifications side by side in the metal. One allotrope must necessarily be in the meta-stable state, and on corrosion these crystals will disappear with greater ease than the others (*e.g.*, α β γ and ferrite, carbon and graphite). One or more compounds may be formed (*e.g.*, Fe_3C, Cementite) which possess definite solution-tendencies different from those of the constituents. Provided uniform distribution of the phases is attained, rusting is likely to be perfectly uniform in character. Immiscible solid solutions of one component in the other may also be occasioned. These are likely to exhibit marked alterations in surface-potential, with its attendant corrosion and pitting.

APPENDIX.

Analyses of Rust.—The following are some analyses of specimens of rust from different sources.

Locality.	Ferric Oxide. Fe_2O_3	Ferric Sulphate. $Fe_2(SO_4)_3$	Undetermined.	Percentage of Iron Sulphat'd (calculated on total Fe present.)
Charing Cross—				
(i.) Wrought iron fallen girder	83·15	8·13	8·72	3·8
(ii.) Gutter outside station	86·37	3·59	9·84	1·7
(iii.) " Paint " scales on platform	57·52	7·07	35·41	4·7
District Railway—				
Cast - iron column Temple Street ...	68·70	9·51	21·79	5·2
Gt. Western Railway—				
(i.) Paddington Terminus	75·08	7·80	17·12	4·0
(ii.) Ditto	74·92	8·05	17·00	4·1
Open country	50·00	1·81	48·18	1·4
Dorchester Cattle Market (Tie rod in roof of an open shed facing S.)	83·47	2·95	13·58	1·4

The high percentage of " sulphate " in towns is very significant indicating as it does, the bad effect of the acids of smoke on exposed iron work.

Influence of Silicon on the corrodibility of iron.—Although the presence of small quantities of silicon is said to increase the corrodibility of iron, when the silicon content is raised there is an apparent decrease. This fact forms the basis of many commercial forms of passive iron. The decrease in corrodibility may be due to the formation of a thin skin of silicic acid on the surface of the metal.

DISCUSSION.

The **President** said he was sure the meeting would agree with him that their best thanks were due to Dr. Rideal for his paper. The paper was one which needed careful reading and consideration in the study after the meeting. The fact that the author had laid the paper before them by stating its purport and adding a running commentary instead of reading it, amounted to the giving of a second paper, and very materially increased the value of the communication itself ; and those members who were not present at the meeting had missed a great deal. The question was undoubtedly of immense importance to all engineers, for he supposed that every engineer had to deal with metallic structures of one kind or another. The author had shown how the scientific method might be applied to the question of the corrosion of iron. This method had one advantage over the older empirical methods, and that was that after investigation they would very probably be no more certain that they would be able to prevent corrosion than they were before. In fact, they were in a position of very considerable discomfort, because they knew that a method which might do perfectly well in one set of circumstances might be absolutely useless under other circumstances, which on the surface might appear to differ very little.

The question of steel pipes was one in which he had some personal interest, as these pipes were now being used increasingly both for waterworks and for gasworks, in consequence of the increase of the pressures which were now being used in distribution. The corrosion of steel pipes was a very serious matter because, as the author had said, the pipe itself was thin, and, if corrosion began, it very quickly spread, and it might begin either on the inside or on the outside. In the case of gas the corrosion began most frequently from the outside, and although steel pipes were wrapped in bitumenised canvas covering, it was difficult to make the wrapping absolutely tight at the joints in all cases so as to prevent contact with the outside ground. The joints were the weak point. They were able by means of oxy-acetylene welding to make a joint which was nearly as good as the rest of the pipe, but, of course, if they were not able to keep the joints from corrosion after they had made them they would be no better off. He hoped that Dr. Rideal would pursue his investigations a little farther, and would be able to show them some infallible method by which corrosion could be prevented.

Mr. C. Humphrey Wingfield noticed that, in the table on page 253, manganese was placed among the elements causing increased corrodibility. It probably had this effect to some extent, but he could give an instance where it was blamed wrongly. When the Thornycroft water-tube boilers were first placed on the market their tubes lasted nine years and upwards before requiring renewal. He remembered one case in which the tubes, which were only 20 B.W.G. thick, were still at work after fourteen years' service.

Then the Admiralty stepped in and began to specify what strength and extensibility the material should possess. He thought the elongation required was 20%. It was found impossible to get this with the tubes then procurable, and after many trials and much expense the Admiralty reduced their demand to 18% elongation.

When next tubes were required the firm was surprised to find the difficulty about elongation no longer existed, and 30% or even 40% could be obtained. It was found, however, that the life of the tubes had been reduced to half its former length.

The question why this was so formed the subject of an investigation, with the details of which he would not trouble the meeting. It was found that those tubes which lasted well contained much less manganese than those which did not, and a minimum percentage of manganese was specified, with somewhat improved results. Later on Mr. Wingfield received a tube from a boiler in Germany which was just as good after some years' work as on the day it had been put in the boiler, and yet on investigation it proved to contain more manganese than the worst English tubes.

The microscope was called into play, and it was then noticed on going over the same samples as before that the structure was much less homogeneous in the tubes which had corroded quickly than in those which lasted well and this was found to be a good test of quality. It was found that the first tubes, made before the Admiralty specified, were made of Swedish charcoal steel, smelted without sulphur-bearing fuel, as the English steels then made were unsuitable for making small solid-drawn tubes.

The addition of manganese enabled steel to be used which was otherwise unsuitable, and was an indication of its use and not the cause of its liability to corrosion. This German steel, though rich in manganese, was of very uniform texture, thus, no doubt, avoiding the local differences of electrical potential to which the author drew attention.

He had for many years used a test for relative corrodibility of two metals which had to be used together, identical with that attributed to Messrs. H. Hanson and W. Lewis (p. 14). Other considerations might, however, be more important. Thus, in one case not long ago where a question arose as to the use of cast iron or wrought steel tubes for lining a deep tube well in which gunmetal plungers, &c., worked inside part of the liner, he found by forming cells with gunmetal-steel and gunmetal-cast-iron (coated with Dr. Angus Smith's composition) that the current was far less with the steel than with the cast-iron. Water from another boring close at hand was used at the electrolyte, and a sensitive galvanometer with an astatic needle was used. Notwithstanding this it was considered that the action of the wet soil on the outside of the tube, where the metal was all of the same nature, was likely to be more important than the electrolytic action inside. This led to the use of cast-iron coated (with Dr. Angus Smith's composition), as a material for the tube. Precautions were, however, taken to insulate the gunmetal parts by ebonite washers and ferrules as far as possible.

He gathered from the paper that a test of this kind, though effective where two metals were in contact, did not show which was most likely to corrode when not connected with the other. The plate which corroded least as part of a couple might be less homogeneous than the other, and therefore get eaten away by local corrosion sooner than the other if exposed to corrosive influences by itself. He would ask if warmth accelerated rusting of cast iron. He had in mind a cast iron tube filled with exhaust steam at a vacuum of about 26 in. of mercury with which an unusual proportion of air was mixed owing to leakage.

This tube was badly rusted with a compact coating of rust, pieces of which could be picked up by a magnet. He did not, however, think it was the black magnetic oxide but that some particles of iron must have come away with it. The tube formed part of a condenser, so that the air was more concentrated near the outside than near the centre of the tube. He believed the rust had formed rather quickly, and should like to know if an excess of air would cause this rapidity of formation in the circumstances.

He was afraid that free lime in cement, suggested the author, as a preventive of rust, would cause expansion and cracking. It was an object with manufacturers to avoid any uncombined lime being present.

He had had some experience with galvanising, both by the hot and electro deposition method. Frankly, he did not believe in the protective efficiency of the latter. It was, however, useful for indicating faults, scales, &c., in the steel treated, as the zinc did not deposit on such places and they showed up black against the white zinc surface surrounding them. If carried out the hot process was a first-rate protection, and did not make the steel brittle. He had investigated this by bending plates backwards and forwards in a vice.

A piece cut from one of the plates of a boat made nearly twenty years before (he had forgotten the gauge, but it was exceedingly thin, less than $\frac{1}{16}$in.) bent as often without fracture as a new piece of the same thickness. No crystallisation had taken place.

A pipe which had been buried in the acid ground near a coppersmith's shop for over four years proved on examination to be in much the same condition as when first galvanised.

The fact was that the acid pickle used for cleaning the plates was not always properly washed off and neutralised, and it remained in the steel, which it ultimately rendered brittle by its action. This was noticed in certain old iron telegraph wires. The zinc was credited with causing the gradual increase of brittleness, but, he believed, unfairly. An analogous case was that of tinned plate. The bottoms of kettles and cans frequently rusted rapidly because the acid used for cleaning the iron before tinning them was allowed to remain.

With regard to paint as a preventive and especially to varnish, examination with the microscope would sometimes show minute pores in the latter through which moisture permeated. Recent experiments showed that, contrary to accepted ideas, one coating of paint was often more effective than several. He should like to know if the author had any theory as to the reason for this.

Many years ago an interesting series of lectures on pigments was delivered at the Society of Arts. The lecturer set himself to discuss why " fugitive " colours when used by the Old Masters were not fugitive, whereas when used by modern painters they soon faded. He traced the cause to damp, and then tested vehicles and varnishes to find one which was damp-proof, but without success. He found that the addition of Venice turpentine made a varnish quite damp-proof, and that the colours then lasted well.

His mode of experiment was ingenious. He dehydrated sulphate of copper by heating on an iron plate until it lost its blue colour. It was pounded and mixed with the varnish. which was then painted on a slip of glass. This was placed in a damp room and left for some weeks. If the varnish was not damp-proof the sulphate of copper became blue, and this was visible on holding it up to the light. This always occurred sooner or later till the Venice turpentine was tried.

Mr. C. T. A. Hanssen said that he was much interested in the rusting of iron, and he had had some experience of pipes and fittings giving way. He had put down a good many galvanised pipes, but found that in using gas tongs for screwing the pipes together the grip of the tongs round the pipe would completely scrape off the zinc coating and expose the iron, which he thought in many cases resulted in rusting. There were usually two places near the ends of each pipe where there was hardly any galvanising left.

Another point was protection by the so-called Dr. Angus Smith Composition. He supposed that that was what the author referred to on page 247, where tar coating was mentioned as being suitable for arresting decomposition. He had used Angus Smith's Composition on ordinary water pipes in very many instances, and it had stood excellently ; but in other cases he had found that it was practically no protection at all. There were waters from deep boreholes in which were found slight traces of sulphuretted hydrogen, quite independently of any organic decomposition, but simply from mineral matter found at a considerable depth in the ground, and this sulphuretted hydrogen had the power of dissolving Angus Smith's Composition. He had had to take up pipes on which it had been used, and had found that the composition, instead of forming a firm coating on the inside of the pipe, was soft like wet shoe blacking, and that the pipes had been attacked by the water. Old Mr. Thomas Hawksley, Past President Inst.C.E., used to specify that the inside of water pipes should be simply coated with a wash of slaked lime. He had seen pipes that had been so treated twenty years before with the coating of limewash still on them, although they had been in water similar to that which had destroyed the Angus Smith Composition. This thin coating of limewash had been put on with a brush and allowed to dry. It seemed hardly credible that such a slight amount of limewash would have stuck to the pipe and have formed a permanent protection.

Some years ago he had to prepare a project for waterworks in St. Petersburg, and he went very carefully into the question as to whether they should have steel pipes, cast iron pipes, or ferro-concrete pipes. There was undoubted evidence that the soft water from Lake Ladoga, where the supply was to be taken, contained a little peat, which was extremely destructive to steel pipes. Such pipes had been used, and they had been pitted just like the Coolgardie pipes, but always from the inside, and they were destroyed in a very few years. It was decided that steel pipes should not be used. The Bonna type of ferro-concrete pipe was a French patent, and was approved by the Russian authorities.

This pipe consisted of a continuous steel jacket strengthened outside by means of a steel coil and longitudinal bars embedded in concrete. Inside there was a lighter steel coil with similar longitudinal bars also embedded in a layer of concrete inside the pipe. He thought that that design answered in many ways to what the author proposed, because the steel jacket made it quite impossible for water to travel through the concrete. There was a perfectly watertight and airtight partition the whole length of the pipe, and the outside coil took the greater part of the tensile stress on the pipe, the rest being taken by the steel jacket, while the concrete formed a dense mass for connecting them together and for protecting the steel jacket and the coils. The inner coil was not reckoned as any increase in the strength of the pipe, but it served to protect the inner concrete lining and connect it to the pipe. These pipes had been in use in France for twenty years, and they seemed to be perfectly reliable, as the concrete formed a perfect protection for the steelwork, and prevented all rusting.

There was an astonishing fact to which the author had not referred. It might be thought that, where the iron in ferro-concrete was rusty to begin with, the rusting would go on under the concrete ; but that was not the case. The rusting of the iron was entirely stopped. In fact, most of the contracting firms who made ferro-concrete preferred to let the iron rust before they embedded it in the concrete, as they said that it helped to form a grip between the concrete and the iron, and that the corrosion of the iron did not increase. That was, he thought, a very important point. He did not know how the iron would be affected if there were a current of water travelling through the concrete. It had been proposed to have ferro-concrete reservoir dams instead of the very heavy and expensive gravity dams that were sometimes generally used for storage reservoirs. He believed that it was very difficult indeed to get any concrete structure perfectly watertight so that it would stand a high pressure of water on only one side. Whether a system such as Bonna's could be applied in such cases to prevent the water travelling through the concrete he did not know. He had not seen it proposed, but he should think that it would be worth considering.

There was another point with regard to the coating with metal. A great difficulty had been found with almost all coatings, except zinc and tin, in applying the coating in such a way that it was non-porous, and that there was absolute metallic contact between the coating and the iron. He believed that when zinc was used they could get such actual metallic contact that the iron could be bent forwards and backwards without injuring the coating, but in the case of other metals, and more especially metals put on by electric action, it was difficult to get such contact between the iron and the covering metal. He had seen copper and nickel scale off in flakes, and it would be interesting to hear the author's opinion as to whether there was any known method of getting metallic contact between the iron and the covering metal.

Dr. Samuel Rideal said that he did not think it quite fair that he should be called on to criticise a paper read by his son. He had already given his son one or two features which he had incorporated into his paper, and therefore he (Dr. Rideal) did not think that he could add much that was useful to the discussion. It always seemed to him that the chemist could be useful to the engineer in more ways than he had been in the past. He would take only the subject of paint. In his practice he had very seldom really been consulted as to the suitability of paints for protecting metals ; and yet the majority of metals were protected by paints. The life of paint and its impermeabilily to water, the evolution of water and carbonic acid in the weathering or ageing of the paint itself, were all problems of very great importance; and yet in his experience he seldom had had occasion to examine paints from that point of view. Quite recently he had one or two in the laboratory sent to him by engineers and surveyors to report on, with the request, "Kindly say whether this is a genuine white lead paint, or whether it is a mixture of white lead and linseed oil." But, after all, the information of that analysis was of very little value to the engineer. What the engineer really wanted to know was whether the paint if it were put on of a certain thickness, would protect the material for a reasonable length of time, and also for how long the particular kind of paint would last before the metal required scaling and repainting. As a rule that was not asked of the chemist by the engineer. Again, sometimes he was asked whether the paint was a quick drier, ignoring altogether the fact that a quick drying paint meant a quickly decaying paint in a good many instances. Therefore he assumed that the engineer risked that particular portion of his work in his specification, and left it to subsequent chances. After it was out of the contractors hands some catastrophe might happen which might have been foreseen and guarded against had a little more time and money been expended on the work in the first instance in ascertaining the actual life and suitability of the protecting material.

Mr. Percy Griffith said that he should like to support Dr. Rideal's suggestion that the engineer, in his ordinary practice did not sufficiently consult the chemist on matters which lay within the province of the chemist and beyond the scope of the engineer, but being himself a culprit he should like to justify the position, in his own case at any rate. He had very great difficulty in getting his clients to consult specialists on points of this character, and, unfortunately, the scale of fees which he could command as engineer did not enable him to remunerate adequately expert geologists, chemists, or any other specialists. Meanwhile discussions such as this afforded engineers some assistance of a general character. The cases he had had in his own experience were in connection with pumps, bore-tubes and chiefly bore-hole pumps. He should much like a hint as to whether or not he was right in the opinion that wrought iron was better than steel for resisting the action of water in bore-tubes, and in borehole pumps or immersed pumps of any sort; and, if it was better, why was it better. He was conscious that this was asking for professional advice to be given to him gratuitously, but this was, perhaps, a unique opportunity for doing so.

The practical point which arose in this connection was that specifying wrought iron tubes meant increased outlay, because wrought iron tubes were seldom made now and contractors invariably asked a higher price for them, and would do their best to get the engineer to accept steel tubes instead.

His other point was more vague, and he could not put any specific question upon it. In the case of a deep borehole pump 18ins. diameter, working in water from the Bunter Beds of the New Red Sandstone, considerable trouble had arisen through a " pitting " action on the pump rods. The pump was what was known as a concertina pump, and the rods carrying the lower bucket had to work through the centre of the top bucket. That was in any event an objectionable feature of this type of pump, but here the " pitting " action took place near the point where the rod passed through the top bucket. Of course in this design of pump there was at this point a very rapid relative motion of the rod through the bucket, due to the one ascending while the other was descending ; and for the same reason the velocity of the water was also very great at that point. Curiously enough the action did not take place where the motion of the water was most rapid, or, at the point of contact betweenthe rods and the top bucket, but at the boss on the rod, just above the point where it worked through the top bucker, and in a corner where there was least motion of the water. A considerable amount of sandy material seemed to accumulate here. He did not analyse this material and therefore was unable to state its nature. It might have been fine sand brought up from the borehole with the water, or it might have been the deposited debris of the corroded metal, or, of course, a combination of both. The action, however, was very marked, and it had involved very frequent repairs to the pump. As the action seemed to be most marked where there was contact or proximity between two different metals—gun metal and steel—it had occurred to him that the action was rather electrolytic than chemical, and he was therefore the more interested in finding that the author of the paper had emphasised electrolytic action as being the most prolific cause of corrosion in immersed pipes and metals generally.

He was now considering the question of using steel or cast iron for about 150 miles of water mains. Both gas engineers and water engineers were very much tempted by the lower cost of steel pipes, but he had in his mind one case, where serious pitting had occurred in steel water pipes and he did not feel justified in taking the risk of using this material. He was also compelled to satisfy a department of the Government which, in the minds of many present, was very old-fashioned and conservative viz., the Local Government Board. He had so often seen the advantage of their carefulness that he was not prepared to join in the condemnation to which the Board were frequently subjected. It was well-known that they objected to the use of steel water pipes in work carried out under their supervision; and the people using them were compelled to pay off the loans in a shorter period than they otherwise would. That, however, might be compensated for by the reduced outlay involved.

He thought that to the discussion of such a question as this, the paper before the meeting was a very valuable contribution, because it would lead the way, he hoped, to a solution of the difficulties which at present militated against the use of steel for water mains, and reinforced concrete for reservoirs. If only the chemist would tell the engineer what ought to be done to render the life of steel pipes equal to that of cast iron, engineers would welcome the advice, and he felt quite sure that their clients would be pleased to pay for it, because of the considerable saving in capital outlay which it would bring about.

Mr. E. J. Fox said that speaking from a steel pipe maker's point of view he might be able to add some remarks of interest to the useful paper that had been read. He had thought that possibly the author's investigations would have resulted in a suggestion for a better method of coating steel pipes than was already known. Although several coatings which protected wrought iron and steel satisfactorily were in general use, finality had probably not yet been reached in this direction, and a coating material was wanted that could be applied on a commercial scale.

His firm alone employed nearly 15,000 men, mostly in the manufacture of wrought-iron and steel pipes, and from this it would be gathered that the volume of pipes to be dealt with necessitated a coating which could be applied both cheaply and expeditiously. He believed that wrought pipes (as opposed to cast iron pipes) suffered to-day largely from being called steel pipes. Many believed that steel lent itself more to corrosion than did wrought iron, and he himself would discourage the use of high tensile steel for these purposes and advocated in preference wrought iron or mild steel. In point of fact, wrought pipes were known as " steel " pipes primarily to distinguish them from cast iron.

Manganese and carbon were the two ingredients present in high tensile steel responsible for the greater tendency towards corrosion. In wrought iron they had about 0.03 per cent. of manganese, in mild steel they had 0.32 per cent., and in high tensile steel they had 0.75 per cent. So far as carbon was concerned wrought iron contained but a trace, whilst high tensile steel contained about 0.32 per cent. " Steel " pipes should therefore be made either of wrought iron or mild steel.

A good form of commercial coating for steel pipes was their old friend Angus Smith's solution, with which the pipe was coated inside and outside. The outside coating was often protected by being covered with a layer of hessian cloth, which acted as a mechanical protection to the Angus Smith solution, while the pipe was being handled during transit and in the trenches. The fact that the pipe with its hessian cloth covering was dipped in Angus Smith's solution a second time gave the pipe an additional protection.

He had been interested in the remark which had been made about cement wash as a coating. He had recently been dealing with a problem where the engineers had expressed a desire to coat some 60 ins. water pipes with cement wash on the inside. Experiments had been made, but, although it was possible to get an excellent coating it would be an exaggeration to say that they had succeeded in obtaining actual adhesion between the metal and the cement. The point of a knife would easily crack off the cement, and, when once it started cracking, it came off freely.

Mr. C. T. A. Hanssen : I said lime, not cement.

Mr. Fox said that he quite realised that, but he thought that the same difficulty would arise in connection with applying lime, At the same time he agreed that some method of applying it might be found which would be useful where the pipes were for use with water.

Turning to another subject. He deprecated the general arguments of the superiority of cast iron *versus* steel, or steel *versus* cast iron for pipes ; for he believed it was impossible to generalise on this subject. But there was one pipe line which had been mentioned by a previous speaker to which he would like to refer : viz., Coolgardie. Nine out of ten Westminster engineers would say, when steel pipes were mentioned, " what about Coolgardie ? " He would like to place on record the following facts in connection with Coolgardie as these facts disproved the general belief that steel pipes *per se* were responsible for the Coolgardie troubles.

First, it was well to bear in mind that the Coolgardie water contained 16 grains per gallon of sodium and magnesium chlorides, which was much in excess of that contained in ordinary water. Secondly in 1890 a cast iron 12in diam. pipe line was laid and gave trouble from corrosion, with the result that in 1897 when further pipes were required it was decided to extend with 21in. diam. steel pipes. Those 21in. steel pipes had not given trouble, in spite of the previous trouble with cast iron. Three years later (in 1900), the well known Coolgardie pipe line was laid, which consisted of about 350 miles of 30in. diam. steel pipes. Trouble arose due to corrosion both internal and external and a commission was appointed to investigate the troubles. He would give in a few words the result of the Commissioners' Report dealing specially with the trouble with regard to the internal corrosion. Apart from the corrosive nature of the water to which he had already referred, air was drawn into the pipe line at intervals, with the result that, under normal working conditions, certain portions of the pipe were never full of water. This was a condition sure to encourage corrosion. The Commissioners advised that the civil engineering work be altered with a view to eliminating this trouble. Nearly £200,000 had recently been spent in this direction. It was certain that the steel pipes should not be blamed for this trouble. As far as external corrosion was concerned, it was pointed out that those responsible for the original scheme had recommended that the pipes should be coated twice before being set to work; in point of fact they were only coated once, and then they were allowed to remain out in the open for about two years before being buried, with the result that the coating was defective from the start. Further, the Commissioners contended it was not sufficient to coat an iron or steel pipe once, because freedom from pin holes could not be guaranteed, and, however small these pin holes might be, moisture was liable to creep in and work its way under the other part of the coating. That was what actually happened. Then, again, this pipe line should never have been buried. The salty nature of the ground was liable to encourage trouble. It is of interest to note, however, that in those portions of the pipe line where the coating was efficient the pipe line is practically in as good a state of preservation as when laid, in spite of the corrosive surroundings.

Take a neighbouring water supply in Australia, namely, Perth. The water in Perth contained 12 grains per gallon of sodium and magnesium chlorides as against 16 at Coolgardie. At Perth they had 12in. diam. cast iron mains and 21in. diam. steel mains, so there was an opportunity of direct comparison between cast iron and steel. Eight years after these mains were laid, the cast iron pipes were found to be so corroded as to require scraping from end to end. This required repeating five years afterwards, and nodules of rust two or three inches thick were removed from the cast iron pipes. With these nodules removed the surface of the cast iron pipe could be cut into with a knife to the depth of about 3/16ths of an inch. The surface below this soft substance was found to be extensively corroded. The steel main was examined after eleven years use and found to be in practically as good a condition as when new. He was not arguing from this that steel was better than cast iron, but he was bringing it forward as one instance, and he might cite many others where steel had proved reliable and where cast iron working side by side had given trouble. In considering the question of corrosion in connection with steel and cast iron pipes it was quite impossible to generalise, as so much depended on conditions, which varied in each case, and it is quite certain that in many cases where steel had given trouble that cast iron would have given trouble—probably greater.

The following written communications were received :—

Mr. William Brown referred to some experiments showing the practical possibilities involved in the study of the subject from the electrolytic standpoint, and supporting the opinion expressed by the author that the electrolytic theory of iron corrosion was the most convincing of the many theories that had been advanced. The experiments were made in America, and the following description of one case is typical of all.

Two polished iron plates, one of them fitted electrically, were lowered over a ship's side into the sea. The electrical equipment consisted of an insoluble anode insulated from the iron plate and connected with the positive terminal of an electric generator, whilst the negative terminal was connected directly with the iron plate. Current at a low voltage having been turned on the plates were allowed to remain in the sea-water (the electrolyte) for 15 days, when the current was stopped. Both plates were then drawn out of the water and exposed to the atmosphere, for 10 days. The control plate was found to be corroded on being taken from the water, the corrosion being extended by the 10 days exposure to the atmosphere. The electrified plate, on the contrary, remained smooth and uncorroded even at the end of the experiment. This result was in keeping with certain explanations given by the author of the principles of the electrolytic theory.

In such experiments as these, when the electric current was turned on, hydrogen was liberated at the surface of the iron plate and corrosion prevented. But further, as the current passed through the sea-water between the insoluble anode and the iron plate, chlorine gas was evolved from the electrolyte, changing to hypochlorite, with the deposition of caustic soda all over the surface of the iron. This deposit accounted for the polished plate being unaffected by the 10 days exposure to the atmosphere after being taken out of the sea.

Following these experiments preparations were now being made to apply the process to a ship 600 feet long. The expectation was that it would effectually prevent rust and barnacles. If this expectation were realised the practical utility of the invention would be very far-reaching. It was also proposed to apply the invention to prevent rusting in ships' water tanks, as well as pitting in propeller shafts.

Prof. Cecil H. Desch wrote :—Mr. Rideal's review of this subject contains much that is of interest. The subject of rusting in reinforced concrete, referred to on p. 242, is of great importance. It is a remarkable fact that well-made, dense concrete not only protects steel from rusting, but actually in course of time removes brown rust (not mill scale) from the surface of steel, leaving it bright. This is due to the action of lime on rust, forming calcium ferrite. The one essential is that the concrete be sufficiently dense to exclude air and percolating water. With porous concrete, not even an excess of lime will protect the steel from rusting, as water is able to enter and the lime is removed in solution. Friend has shown that under certain conditions steel will rust even in presence of alkalies. Stray currents have often caused serious rusting in reinforced concrete. Rusting of the steel reinforcement is particularly dangerous, as the expansion caused by the formation of rust causes disruption of the concrete, and the formation of even fine cracks greatly accelerates the evil.

The rapid corrosion of iron pipes embedded in a cement containing magnesium oxychloride (p. 245) points to the necessity of protecting the metal very perfectly in such cases. The use of flooring of this kind on board ship has in several instances been abandoned on account of the destruction of the steel joists carrying the floor.

In regard to methods of testing (p. 251), the writer is of opinion that accelerated tests involving the use of acid are worthless for the purpose of comparing the resistance to corrosion of different materials, but that an electrolytic test, in which the metal is made the anode under suitable conditions in a neutral electrolyte, may be made to yield most useful results. It is not, however, sufficient, as is often done, to determine the loss of weight of the anode, as several distinct effects are thus confounded. By the use of combined chemical and microscopical examination during the test, the process of corrosion may be studied in detail.

Mr. Rideal's paper forms an excellent basis for the discussion of this very important subject.

Mr. A. S. Everett wrote :—Perhaps my experiences of the rusting of iron water mains are not uncommon, but the undermentioned case presents some special features.

Rather over a mile of 2in. coated cast-iron main was laid down in 1907, for the supply of a large country house in Devonshire. There is a difference in level of about 170 ft. between the collecting tank and reservoir at the spring, and the point of distribution. The source of supply is a small spring flowing at about 1 gallon per minute, and of remarkable constancy, as it has not varied appreciably at different times of the year, nor in either excessively dry or wet seasons. It has been analysed at intervals of six months for several years, and the constituents given below do not alter their proportions. (*b*) was collected at spring and (*a*) from the 5 gallon reservoir at a Pasteur filter.

	*a.** Grains per gallon.	*b.*† Grains per gallon.
Total solids	5·8	8·05
Chlorine as chlorides	1·96	1·40
Ammonia (free)	0·001	0·005
Ammonia (albuminoid)	0·008	0·004
Nitrogen as nitrates	Faint trace.	0·000

* "This is a very soft water and very pure organically, and well adapted for household use."

† "The analytical figures show that the water is in excellent condition."

Discolouration of the water has occurred ever since the supply was installed. Repeated washings out of the main seemed to have merely a temporary effect, the rusting becoming again evident 2 or 3 weeks afterwards. The analyst states that the analysis is not that of a water likely to attack metals. All ironwork, however, is readily corroded, while such metals as copper and brass retain an unusual brightness in contact with the water. On reaching the storage tank at the house, a certain amount of the matter in suspension was deposited, but much discolouration remained. In the cemented reservoir at the spring, the appearance and taste of the water was uniformly excellent.

The gradient of the main is practically uniform, down to within 200 yards of its lower end, whence it rises some 10 ft. gradually up to the building, and then vertically 35 ft. through the house. The only way in which the water could be kept reasonably clear was to close down the stop-cock on the main, so as to admit it to the tanks at the house by ball-cock control very slowly. If allowed to flow with the natural discharge, it was so discoloured as to be unusable. Even with this plan, periodical flushing was necessary.

Eventually I tried another means. There being no service off the main until this reached a point ¼ mile from the house, and some few feet difference in level from the point of supply to the tanks on the roof, I decided to reduce the pressure on the main by allowing it to act as an open channel down to the first point of service above mentioned, and I further caused the flow through the whole pipe to be uninterrupted, continuous overflow taking place at the service tanks when these became full. Service at the earlier point referred to was ensured by the fixing of a weighted relief valve at the lower end of the main, by means of which sufficient pressure was obtained to effect the service before the house tanks were filled and overflow took place.

The result was quite satisfactory as regards the discolouration and taking up of iron that occurred previously, the only disadvantage being the loss of head for fire purposes, etc. I have been informed that an excess of oxgyen in the water, which is from a Greensand formation, may account for its corrosive properties. It is evident that reduction in the pressure, and in the time the water was in contact with the pipe, had beneficial results.

Dr. J. Newton Friend, wrote :—Dr. Rideal has given a very useful and interesting summary of the present position of our knowledge of the corrosion of iron and steel. Few subjects offer such opportunities for fruitful discussion and for wide divergence of opinion. It is inevitable, therefore, that numerous statements must be made, in a short paper such as this, to which exception may be taken or acceptance given according to the standpoint of the reader. It is important to remember, however, that facts must always remain ; it is their interpretation which may vary as our knowledge increases.

A few assertions have been made which do not quite coincide with my experience and I venture to draw attention to two of these in the hope that the author may give us his views a little more fully and thus enable us to arrive at some useful conclusion.

On p. 253 a table is given grouping the names of elements which when alloyed with iron have certain marked influences upon its rate of corrosion. In the first column are those that induce an increased corrodibility and amongst them we find manganese and silicon.

That manganese tends to increase the corrodibility of iron is a tradition that has been handed down for nearly a century. Mallet,* in 1838, quoted Berthier as one of the first to call attention to it, and the observations of Siemens** in 1878, of Snelus† in 1881, of Finkener,†† in 1897, and of Cushman,‡ in 1905, would seem to have confirmed the view. But when we approach the subject with an impartial mind we are bound to acknowledge that the problem is not quite as simple as it appears. Out of the numerous samples analysed by Cushman in 1905, several very resistant to corrosion were observed to contain as much as 0.4 per cent. of manganese, whilst others containing the same amount were highly corrodible. This observation alone is sufficient to indicate that some other factor is at work.

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* Mallet, *British Assoc. Reports*, 1838, p. 265.

** Siemens, *J. Iron Steel Inst.*, 1878, II., 425.

† Snelus, *ibid.*, 1881, I., 66.

†† Finkener, *Mitteilungen aus dem koeniglichen technischen Versuchsanstalt*, Berlin, 1897, 15, 277.

‡ Cushman, *Farmer's Bulletin*, 239, U.S. Dept. Agriculture, 1905.

As everyone knows, manganese is added to ordinary steel in order to remove the sulphur, and only a relatively small proportion of it remains behind in the steel. But most of this residuum is usually in the form of sulphide ; and it is quite possible that manganese has suffered in reputation through its association with sulphur, which latter element is well known to have a most deleterious action upon iron by virtue of its easy oxidisibility. This supposition is supported by recent research. In 1908, Heyn and Bauer* showed that by increasing the manganese content of a cast iron from 0.46 to 3.08 per cent. but keeping the sulphur and other elements constant, the corrodibility fell from 100 to 89. More recently still Burgess and Aston,** to whose work, it is interesting to note, Dr. Rideal himself refers, show that, by alloying manganese with a relatively pure iron, the corrodibility undergoes a marked reduction.

Whilst these experiments are hardly to be regarded as final they certainly give us good reason for believing that manganese should not appear in column 1, but rather in column 3 of the table on p. 253.

Copper steels have had a precisely similar history, the sulphur of the copper sulphide causing the steels in early years to corrode rapidly. Thus copper fell into disrepute. The recent researches of Stead,† Breuil,‡ and of Buch¶ have clearly demonstrated that copper, in the absence of sulphur, greatly enhances the resistance of steel towards corrosion. The author rightly places copper in the last column.

The case of silicon is both interesting and complex. It must always be borne in mind that the influence of silicon upon a carbon alloy of iron is complicated by the fact that it tends to throw out the carbon in the form of graphite. Consequently both the chemical condition of the carbon and the physical condition of the metal is altered. We have thus two additional and very important factors to consider which may affect the corrodibility of the metal as much as or even more than the silicon itself *per se*. In cast iron the increased porosity caused by the separation of graphitic carbon frequently induces an increased corrodibility. But it is not the silicon *per se* that does it. In fact if carbon is present in only small proportions the silicon tends to retard corrosion. Silicon steels rank with nickel, chromium, and copper steels in resistance to corrosion, and silicon should have appeared in the fourth column on p. 253, and not in the first. This fact has been recognised in the engineering world for several years. W. Hanson,* writing in 1909, drew attention to the corroding action of the hot, damp and rank vegetation surrounding the rails on the Fijian sugar plantations and the fact that ordinary steel rails soon perished. Since the introduction of high silicon rails the trouble had been largely overcome. Numerous other examples might be quoted, but this will suffice. The above are very important points. From a perusal of the paper an engineer would conclude that manganese and silicon steels are to be avoided as readily corrodible—which they are not of necessity.

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* Heyn and Bauer, *Mitteilungen aus dem koenglichen Material-prüfungsamt*. Berlin, 1908, 26.

** Burgess and Aston, *VIIIth International Congress Applied Chemistry*, 1912. New York.

† Stead and Wigham, *J. Iron Steel Inst.*, 1901, II., 1.

‡ P. Breuil, *ibid.*, 1907, II. 1.

¶ D. M. Buch, *Iron Age*, April, 1913.

Dr. Rideal is to be congratulated on his paper. It is a difficult subject and the literature is both voluminous and scattered.

Mr. F. W. Harbord referring to the pitting produced by mill scale, wrote that although mill scale may in many cases be a contributing cause, by far the greater part of steel employed for pipes and similar work is used as it comes from the rolls, partially covered with scale. Again rivets, after heating and driving, are partially covered by scale, and if this had as much influence as some authorities would have us believe, the failures from corrosion would be far more frequent than they are; although not disputing that under certain conditions corrosion may be due to electrolytic action started by scale. I think its effects have been somewhat exaggerated.

The prevention of corrosion is one of the most serious things with which the engineer has to deal and it depends entirely upon the conditions under which the steel is to be used as to what are the best methods of prevention. Although the electrolytic theory may not fully explain the phenomenon of corrosion I agree with the author that it does offer a reasonable explanation in the vast majority of cases.

The deposition of a thin protective coating by addition of lime to water, mentioned by the author, is often most effective. Some years ago a boiler using very soft pure water began to pit after a few weeks work, but after having the plates thoroughly cleaned, a little lime was added to the water for a few days, a thin coating was deposited, and the boiler worked satisfactorily for years with the same water. From my experience I have found the best mechanical coating for exposed metal surfaces to be pitch mixed with some hydro-carbon oil, and when appearance is not of importance it gives better results than paints.

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* W. Hanson, See Dicsussion on Edward Crowe's Paper on Corrosion, *Proc. Cleveland Inst. Engineers*, March 1, 1909, p. 172.

It is extremely difficult to get any satisfactory practical test of corrodibility, as local conditions, which it is impossible to reproduce in the laboratory, have such a marked influence. It is generally assumed that wrought iron behaves better than steel and this is undoubtedly so in some cases and quite recently I investigated a case of corrosion where one plate was eaten away rapidly and another not appreciably attacked. In this case the only difference as far as could be learnt was that the one which failed was mild steel, and the one that gave good results wrought iron. This, however, is by no means always the case and under certain conditions I have found steel behave quite as well and in some cases better than wrought iron, so that no wide generalizations are safe.

Although the different constituents in steel such as ferrite, cementite, etc., may have different solution-tendencies I hardly think these have any appreciable effect from a practical standpoint, as all steel contains these in various percentages, and the presence of such impurities as sulphide of manganese, sulphide of iron, etc., and similar impurities, especially if present in abnormal quantities, are far more likely to have detrimental effects.

Reply.

Dr. Eric K. Rideal, in replying to the discussion, said that he did not stand there to say whether steel or wrought iron was the better material. He was not actually interested in either. He could only say, as other people had said, that sometimes steel was the more suitable and sometimes cast or wrought iron. He would refer those people who were interested in the question to the work of Rudeloff, in Germany in 1902, and Howe and Stoughton, in America in 1908, who investigated the merits of steel and wrought iron side by side. He thought he might say that they came to the conclusion that one was as good as the other for general purposes, but of course special conditions might militate against the use of one or the other. He thought that the real point about steel mains was that they were thinner than cast iron for certain work, and if the corrodibility of steel and of cast iron by a given water were the same, the corrosion from all practical tests, was likely to be more localised in the case of the steel pipe than in the case of the iron pipe. In steel they had much more segregation than they had in the wrought iron; and it was that segregation that caused localised pitting. This might be prevented either by removing the mill scale entirely, by painting it, or by some other process. The problem of all localised pitting might be got over. It was simply a question of care, either in manufacture or in after treatment.

With regard to the question of galvanised iron pipes, Mr. Hanssen had remarked that the tongs used to grip the pipe cut up the zinc ; and of course a chisel and the process of bending a pipe might remove the zinc from the surface of the iron.

As to the question of the proper method of coating an iron pipe with zinc, whether one should use the process of sherardising or dipping, or electrolysis, a good deal depended on the care bestowed on it. When an iron pipe was directly coated with zinc, the iron was very often " dipped " in an acid chloride solution before it was put into the bath of molten zinc ; and, if the acid was not removed from the surface of the iron, they would get an inclusion of iron and zinc chlorides between the zinc and the surface of the iron. That was a condition that was favourable to electrolytic corrosion setting in. It was not due to the water in contact with the pipe, or to the ai , or to the soil, but actually electrolysis was set up between the zinc and the iron in the process of galvanizing. The advantage of sherardising was claimed to be, as they had been told, that zinc dust was blown on to the iron in the process. First of all at the surface of the iron a solid solution of zinc and iron was made ; then the metals entered into a definite chemical compound, and finally if sufficient zinc were applied a pure zinc coating might be formed. If this was true, they could see the reason that the colour of a sherardised piece of metal was not so bright and had not the same metallic appearance as was produced in the process of dipping or by electrolysis. This was due to the alloy of zinc and iron. But he thought that, other things being equal, if the sheradising process was properly conducted it would be just as good as either dipping or electrolysis.

A lot of practical problems had been brought up on the question of lime and cement, and how to coat pipes with lime or with cement. He could refer those interested to the report of the Corrosion Committee of the Institute of Metals. Dr. Benbough had found cases of calcium carbonate being deposited on metal so thinly that it was translucent, but it still exerted a certain protecting effect. He suggested to those people who wanted to protect their iron by calcium carbonate that they should *make the water do it,* which they could do by proper chemical treatment and a proper process applied to that water. It was true that they could deposit calcium carbonate from the water, and it only remained to find the right conditions. These had been in some cases accidentally, and in others experimentally arrived at ; but the fact remained that calcium carbonate could be coherently deposited on the iron from the water.

He had been interested to hear the action of peat water on iron ; of course, peat water, as they knew, contained a large amount of carbon dioxide, an acid which accelerated corrosion.

The case of the exhaust pipe through which steam was blowing was an interesting one. He thought that there were two inferences. The steam itself probably contained a little acid, and the high temperature augmented the rate of corrosion, but another influence was at work; when iron corroded, a certain amount of hydrogen was deposited at one pole; and the removal of the hydrogen which was essential for the continuance of the corrosion was usually brought about by the atmospheric oxygen. When the steam was blowing through the pipe, the hydrogen which was formed by the process of corrosion was removed more readily by the wet steam, and the corrosion was augmented. He thought that, possibly, that was the explanation.

A question was raised as to the scaling of nickel off iron. That was rather a complicated problem, and it was caused by the liberation of hydrogen on the surface at the time of plating. Nickel was rather brittle, and, if some means could be found for preventing the liberation of hydrogen at the same time as the deposition of the metal, a much more suitable deposition could be caused. When they wanted to coat iron with copper or nickel or some other material which did not easily deposit they should first deposit some different metal which would make a good contact between the iron surface and the metal which was to be deposited. The chemist had a series of metals which were applicable for the different purposes and which admitted of practical application on a large scale.

The question of paint had been raised by Dr. Samuel Rideal, and the paint problem was an important one from all points of view. He thought that there were certain well defined tests which might prove useful, and although they were new tests that fact did not militate against their worth.

He had not referred to the question of anti-foulers for the bottoms of ships. For that purpose the paint had to consist of something which offered very little resistance to the flow of the water. It generally consisted of a skin of varnish, on the top of which was a poison, and another coating of some medium. The poisons usually employed were mercuric chloride, oxide of copper or oxide of iron. He thought that the right choice of the poison and the right choice of the varnish might produce a very suitable and permanent anti-fouling paint.

As regarded the question of manganese and carbon in iron he thought that some persons rather regarded manganese as a friend in disguise. Manganese *per se* did not exert a bad effect on iron, but he did not think that he could regard that as conclusively proved. When they got the figures, for the carbon manganese or oxygen content, he thought that they were more or less useless unless they were able to tell the nature of the distribution of the impurity in the iron itself. The chief danger in corrosion from the point of view of the practical engineer was when it became localised. If the oxygen was equally distributed over the whole surface of the metal, no corrosion would take place. That was the Bower-Barff process. The analysis of iron which had been treated by that process should give iron so much, and oxygen so much. Perhaps people would say that that iron would be very liable to corrosion as it contained oxygen, but as a matter of fact it stood very well indeed.

Mr. Brown's experiments on the prevention of rusting in sea-water by means of an electric current are interesting; it is not evident, however, that the formation of hypochlorite of sodium was a factor in the process since the hydrogen liberated during the electrolysis of sea water is chiefly a secondary chemical reaction caused by the interaction of the sodium liberated by the electric current with the surrounding water, soda being formed at the same time. The same cathodic reaction takes place in solutions of sodium sulphate as well as in those of sodium chloride.

The author agreed with Professor Desch's statement that loss of weight experiments were very misleading as corrosion tests unless information were forthcoming as to whether that loss was uniformly distributed over the metal surface or localised in "pits." Microscopic observation was undoubtedly one of the chief resources of the investigator.

The circumstances of corrosion investigated by Mr. Everett seem to indicate that his modifications have not decreased the corrodibility of the water but have prevented the rust film inside the pipe from getting disturbed and thus allowing it to protect the inside of the pipe. The analyses indicate a low total solid content but do not include a dissolved oxygen or a CO_2 content figure which are of importance in this connection. If the carbon dioxide content were high, chipped marble in the cemented reservoir might remedy the ferro-solvency, on the other hand if the oxygen figure exceeded normal proportions, as Mr. Everett suspects, more drastic treatment would probably be necessary.

In the case of manganese and silicon irons and steels, to which Dr. Newton Friend, who is one of the most indefatigable workers in England on this subject, had drawn attention, the author had already indicated that a high silicon content exerted a protective influence on iron and he suggested that this action was due to a superficial coating of silicic acid and not due to silicon *per se*; he agreed with Dr. Friend that the fate of manganese was rather on the knees of the gods at the present time.

Mr. Harbord's experiences with a wrought iron and a steel plate in which the mild steel was attacked and the wrought iron not attacked seemed to indicate that the steel corroded at the expense of the iron; an actual difference of potential may have existed between the two plates, causing the steel as a whole to act as a protector metal.

ANNUAL GENERAL MEETING.

The Fourth Annual General Meeting of the Society, was held at the Offices of the Society, 17, Victoria Street, S.W., on Monday, December 8th, 1913, the President, Mr. Arthur Valon, M.Inst. C.E., being in the Chair.

The Secretary read the Report of the Scrutineers on the result of the postal ballot for the election of the Council and Honorary Officers for the year 1914, and announced the awards of premiums made by the Council in respect to papers published in the JOURNAL during 1913 (see page 279).

The Report of the Council was read and adopted. (See next page).

Messrs. Begbie, Robinson and Cox, Chartered Accountants, were elected as auditors for the ensuing year.

A vote of thanks to the Council and Officers for 1913 was proposed, seconded and carried unanimously.

A vote of thanks was passed to the Scrutineers, Messrs. W. C. Easdale and A. S. Everett for their services in connection with the ballot for the election of the Council for 1913.

A unanimous vote of thanks was passed to the authors of papers published in the Journal during the past year.

REPORT OF THE COUNCIL FOR THE YEAR 1913.

Your Council in presenting their fourth Annual Report since the amalgamation and incorporation of the Society regret to have to record the deaths of Sir Wm. Henry White, K.C.B., LL.D., F.R.S., (Honorary Fellow), Sir William Henry Preece, K.C.B., F.R.S. (Honorary Fellow), and of Mr. James R. Bell, M.Inst.C.E. (Member of the Council).

One of the vacancies on the roll of Honorary Fellows has been filled by the election of M. Gustave Eiffel, ancien président de la Société des Ingénieurs Civils de France, whose scientific researches, particularly in connection with wind pressure and aeronautics, are well known.

MEETINGS.

The Council have met eleven times during the past twelve months, and there have been 37 meetings of Committees, in addition to seven Ordinary Meetings.

PAPERS.

The President, Mr. Arthur Valon, M.Inst.C.E., delivered his Inaugural Address on March 3rd, and dealt with a number of questions relating to the education of engineers, and the organisation of the profession.

The following gentlemen have contributed papers for reading at meetings and for publication in the Journal during the year 1913:—

Mr. Bernard L. Rigden, " The South Eastern Coalfield."
Mr. Wm. Yorath Lewis, " The 'Bus *v.* Tram Controversy and other aspects of the London Traffic Problem."
Mr. Wlliam Ransom, Status Prize Essay.
Mr. C. A. Battiscombe, " Tidal Waters as a source of Power."
Mr. Louis S. Spiro, " Reconnaissance Surveys " and " Precision in Engineering."
Prof. F. H. Hummel, " Testing Centrifugal Pumps."
Mr. Reginald Brown, " The National control of Rivers and Waterways."
Mr. C. H. Cooper, " Highways."
Mr. Gerald O. Case, " Accretion at Estuary Harbours on the South Coast of England."
Dr. Eric K. Rideal, " The Corrosion and Rusting of Iron."

PREMIUMS.

The Council have awarded the following premiums for papers contributed during the year :—

The PRESIDENT'S GOLD MEDAL to Dr. Eric K. Rideal for his paper on " The Corrosion and Rusting of Iron."

The BESSEMER PREMIUM, Value £5 5s. to Mr. Bernard L. Rigden for his paper on " The South Eastern Coalfield."

The CLARKE PREMIUM, Value £5 5s. to Mr. Gerald O. Case for his paper on " Accretion at Estuary Harbours on the South Coast of England."

A SOCIETY'S PREMIUM, Value £3 3s. to Mr. Wm. Yorath Lewis for his paper on " The 'Bus *v.* Tram Controversy and other aspects of the London Traffic Problem."

VISITS.

Three half-day visits to engineering works took place during the Summer vacation as follows: —

June 17th.—The Chingford Reservoir of the Metropolitan Water Board, and Humphrey Pumps.

September 2nd.—H.M. New Stationery Office and H.M. Office of Works Stores.

September 30th.—Extension of the Baker Street and Waterloo Railway, Kilburn.

FINANCE.

The various statements representing the financial position of the Society at the end of the year 1912 as audited by Messrs. W. B. Keen & Co., Chartered Accountants, were published in the JOURNAL for March, 1913.

As the Income and Expenditure for 1912 showed a small excess of expenditure over income the Council have very carefully examined the financial position of the Society with a view of ascertaining whether the normal expenditure was likely to exceed the normal income. They have satisfied themselves that this is not the case, and can confidently state that the financial position of the Society is perfectly sound. Beyond this the Accumulated Fund, amounting to over £800, affords an ample reserve against any temporary deficit, and the Council, by close supervision of expenditure, hope to avoid any permanent depletion of this fund without sacrificing the utility of the Society's work.

LIBRARY.

The Council have appointed a special Committee to deal with the Society's library, with a view to eliminating therefrom any volumes that are not likely to be useful to the members, and also to classify the remaining volumes so that they may be more easily accessible for reference. The Committee presented a report to the Council and have been authorized to take the necessary steps for giving effect to their recommendations.

A catalogue of the books in the library will shortly be issued to the members, who it is hoped will assist to make the library more complete by the presentation of recent books likely to be useful to their fellow members.

EXAMINATIONS.

The Council desire to call the special attention of the Memebers to the fact that the syllabus of examinations for the Fellowship of the Society is now completed and a very influential list of examiners has been obtained. They do not anticipate that there will be a large demand for these examinations but they suggest that members will find it to their advantage to be able to point to the Fellowship Certificate as evidence that they have a sound theoretical and practical knowledge of Engineering.

BUSINESS DIRECTORY.

The Council desire to impress on members the advantage that they may gain by having their names recorded in the Business Directory. This Directory is quite distinct from the Appointments Register, and forms a record of the qualifications and experience of the members, and information as to the particular branches of engineering engaged in by them. It is intended for reference when inquiries are received for names of Engineers who can undertake some special class of work whether in a consultative or other capacity as principals.

All members of the Society who are engaged as indicated should have the particulars of their work recorded and for this purpose are requested to supply the necessary information (see below). It will be a convenience if the information is typed or neatly written on one or more 5in. by 3in. card-index cards (which may be obtained from the Secretary), both sides of which may be used.

The following particulars should be given :—

(1). Name to be written in the top left hand corner of the card in block type, *surname first*.

(2). Address, telephone number and telegraphic address.

(3). Degrees, diplomas and other distinctions, including membership of scientific societies.

(4). A brief resumé of the principal work undertaken.

In the case of those whose names are already in the Directory it would be advisable for them to send in a new statement unless they are satisfied that their present records are complete and do not need revision. No charge of any kind is made in connection with the Business Directory and any further particulars desired may be obtained from the Secretary.

APPOINTMENTS REGISTER.

The Appointments Register, which has proved its worth during the past few years, can still be further increased in usefulness if a larger number of employers in need of assistants, and assistants seeking new positions would send on particulars of their requirements to the Secretary. Detailed particulars may be obtained at the offices of the Society.

LEGAL ADVICE.*

Arrangements are in force by which members may obtain free legal advice on professional matters, and the Council are pleased to state that they have recently made further arrangements whereby members can obtain free advice on patents, trade marks, designs or copyright. The Council invite the members to make use of these advantages, particulars of which may be obtained from the Secretary.

ATHLETIC CLUB.

By the courtesy of the Architectural Association, arrangements have been made whereby members of this Society may be admitted as members of the Architectural Association Athletic Club, which has its ground at Elstree. Particulars as to terms of subscription were published in the JOURNAL for June last, and can be obtained on application to the Secretary.

COUNCIL AND OFFICERS FOR 1914.

The Scrutineers appointed to examine the ballot lists received in connection with the election of the new Council have reported that the result of the postal vote is as follows :—

President.—H. C. H. Shenton.

Vice-Presidents.—Norman Scorgie, T. E. Bower, Percy Griffith.

Members of Council.—Henry Adams, C. T. Walrond, Henry C. Adams, S. Cowper-Coles, B. H. M. Hewett, F. H. Hummel, G. A. Becks, F. L. Ball, C. W. V. Biggs, W. B. Esson.

Associate Member of Council.—R. J. Simpson.

Hon. Secretary and Hon. Treasurer.—D. B. Butler.

The Report is signed by Messrs. W. C. Easdale and A. S.

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* It was pointed out at the Annual General Meeting that the Society pays the Solicitors for their advice under this arrangement.

Everett, to whom the thanks of the Society are due for their services as scrutineers.

STATUS OF THE PROFESSION.

The Council have been for some months past engaged in the consideration of the difficulties under which our profession is practised at the present time with a view to suggesting some course of action that would be advantageous not only to the members of the profession, but to the public whom they serve.

A strong Committee has been appointed to consider the question but they have not yet submitted their final report to the Council. They have, however, briefly represented the present unsatisfactory condition of affairs, and have made a definite proposal which the Council consider worthy of being adopted forthwith.

The Committee fully appreciate the fact that the evils complained of are not alone due to any failure on the part of members of the profession. Other matters such as the practice of inviting competitive quotations of fees from a number of engineers, the advertising of competitions for engineering designs, the acceptance of designs as well as tenders from manufacturing firms, without competent and independent professional advice, and especially the tendency of municipal authorities to appoint engineering officials on the strength rather of the smallness of the salary demanded than of the qualifications offered—have all adversely affected the status of the profession.

The Council have therefore readily acceded to the request of the Committee that the *members should be specifically invited to send in records of any cases which have come under their personal observation, in which the interests of the profession generally or of individual members in particular have been prejudiced.* Such records may be supplied without names or with a reservation that the names are to be considered confidential, and the Council pledge themselves that such reservations shall be rigidly respected.

Envelopes containing correspondence on this subject should be marked "Status: Confidential" and addressed to the Secretary, who will submit them unopened to the Council.

17, VICTORIA STREET,
WESTMINSTER, S.W.
8th December, 1913.

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NOTE.—A complete index to the Transactions of the old Society of Engineers will be found in the last volume published by that Society, and the volumes of Transactions of the Civil and Mechanical Engineers' Society are also indexed.

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